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TECHNOLOGY TRANSFER IN SCIENCE, TECHNOLOGY AND PUBLIC POLICY,(U)

1978 J A JOLLY, J W CREIGHTON, B M MOORE

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TECHNOLOGY TRANSFER IN SCIENCE, TECHNOLOGY AND PUBLIC POLICY

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PREFACE

The students in the 1977/78 class of the Graduate Program in Navy Executive Management, offered and conducted by the Naval Postgraduate School, Monterey, California, participated in a Seminar on Science, Technology and Public Policy, The seminar was offered four hours per week for eleven weeks. Twenty-seven government employees who were employed by the Naval Air Systems Command, and were members of the Naval Aviation Executive Institute, participated in the masters level program. They had been selected for the program because of their high potential as managers and because of their past superior performance as members of middle management. The students had civil service ratings of GS-13, GS-14, or GS-15. All had undergraduate degrees, which in most cases were in one of the scientific areas. A few of the students had masters degrees in scientific subjects.

The format of the seminar was built around invited guest speakers, tapes of speeches, and discussions of readings.

During the final weeks of the seminar, each student was asked to write an essay. The instructions were as follows: "The essay should be developed by a review of known facts and strengthened by quotations and/or paraphrases from several articles and/or books listed in a bibliography. (The bibliography was distributed to the class.) The essay should lead to a logical conclusion either resulting from original thinking or based upon the suggestion of some properly referenced work.)"

Ten of the twenty-seven essays were selected for the chapters of this book. They cover a rather wide range of thought and make what we believe to be a substantial contribution in presenting the development of thought that resulted from a very intensive academic experience.

(1) The first essay, "Technology Interactions with Public Policy," was written by William Burlem. The concept that technology is sometimes curtailed by public policy is not new. Burlem has, however, developed a model of public policy that gives an insight into the relationships among the stages of national development and technological progress. The concept discussed in the essay may provide a better understanding of the stage of advancement of any developing nation.

(2) John Sweeney in his essay, "Technology and Economics: Problems or Answers," probes the underlying cause of the present energy and pollution problems. What is the relationship of technology and economics? Sweeney has hypothesized that much of the problem lies outside of known relationships and can be best described as errors of public policy. Public policy can distort the relationship of technology and economics to such an extent that a major dilemma can occur.

(3) The third essay, "Technology: No Policy for Giants," by Milton Olsen discusses the concept that technology is a momentous giant, growing, subdividing and causing persistent changes. The theme presented by the author suggests that it should be possible to use our advanced management technology to generate systems to set public policy and consequently manage and direct our technology toward purposive benefits for mankind.

(4) The fourth essay, "International Technology Transfer: Ramifications Concerning Communist Bloc Nations," by Howard Fish, causes the reader to review the position of the U.S.A. as a source of technology for the world. Although security and economic factors are important, his essay looks at the impact of technology on traditional cultural patterns. The examples in the discussion are the People's Republic of China and the Union of Soviet Socialist Republics. A critical inspection of technology processes in these two dominant nations elicits consideration of our public policy.

(5) The fifth essay selected for this book has the title, "The Effect of Climate on Food Production and Population." Its author, Theodore Elsasser holds the premise that any change in the world climate would be catastrophic. He reviews the inputs to the paradigm. This review clearly illustrates the intense sensitivity of the system and how technology has disrupted its equilibrium. Elsasser suggests a mandate for survival.

(6) The mood of the people of the U.S.A. is not one of confidence and anticipation, but one of concern for the long-term survival of human beings, according to James Thaler. His essay, "World Population Explosion: A Technological, Not Fertility, Crisis," argues that it is necessary to adopt a public policy to reverse technological colonialism induce economic growth in order to resolve the existing crisis.

(7) Joseph Rezin has prepared an innovative essay, "The Computer: It Leadeth Man to Think." In the past, unless a public figure had a scientific background, he would not have been schooled in the systems approach to problem solving. Rezin observes that the future may be quite different. The computer drives all educated people into a form of disciplined thinking. This concept has implications for public policy decisions.

(8) The eighth essay, "Computers, Privacy, and the American Public," by Kenneth Suess, reminds the reader that we have only seen the initial impact of the computer on our society. New technology must attain a balance between benefit to man and the threat to his survival. During the first twenty-five years of the computer, one undesirable implication has been the threat to privacy. This is a public policy issue which is effectively reviewed by Suess.

(9) Public policy tends to reach into unexpected areas of the manager's prerogative; at least, this is the view of many managers. William Winner, in his essay, "Product Liability, and How the Engineer and Small Business Manager Can be Prepared," presents a careful discussion of the background of the problem and some logical recommendations on how to prepare for the future.

(10) Solar energy is emerging as a technological concept of major importance to our society. Peter Hughes discusses one aspect in his essay, "Solar Heating of Homes—A Technology Assessment." According to Hughes, it is highly likely that, as a result of public policy, we will eventually live in a solar energy controlled climate. He presents arguments to support this view.

The essays speak for themselves. In total, they present the perceived mood and direction of the interrelated forces bounded by science, technology and public policy.

They are enjoyable reading, providing an informative, thoughtful, and significant contribution to the literature of technology transfer. As editors, it is with sincere appreciation that we extend thanks to each of the authors whose essays appear in this book. Printing of this book was made possible through the cooperation of the Naval Aviation Executive Institute.

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Chapter I

TECHNOLOGICAL INTERACTIONS WITH PUBLIC POLICY

by

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ABSTRACT

This paper examines past and projected interactions between technological developments and public policy. Three stages are suggested:

> Stage I — Technological feasibility shapes public policy.
>
> Stage II — Technology is curtailed by public policy.
>
> Stage III — Technology is utilized in support of public policy.

Stage I began with the industrial revolution, and phased out as Stage II commenced immediately after World War II. While the character of Stage I was primarily positive, that of Stage II is negative. Stage III has yet to be entered. Prerequisite to this stage is the formulation of national goals and objectives.

This final stage will yield the greatest benefits to society from technological developments due to an integrated scientific/social approach to the achievement of consensus national commitments.

OBJECTIVE

"Progress is our most important product." Sound familiar? How about "As we move into the decade of the seventies we have the greatest opportunity for progress at home of any people in wo..d history." (President Nixon, 1970).

"Progress" means different things to different people depending upon their perspective. In the former instance, one presumes that making the American kitchen (and the lives of company stockholders) less labor-intensive is "progress." In the latter, one guesses that "progress" means an improvement in the equally vague "quality of life." Nor is Websters' New Collegiate Dictionary of much help in coalescing possible meanings:

"Progress 1. To move forward; to proceed. 2. To develop to a higher stage." Forward to where? What higher stage? While an old Chinese statement that "Progress is made by the constructive confrontation with obstruction" (Dhiegh, 1975, p. 48) is beautifully presented, it suffers from the same presumption that a purpose for progress is apparent.

The possibility of dissention is significantly reduced when politicians espouse "progress" while leaving the interpretation of its direction to the listener. It is in the political arena, however, where the lack of clearly specified targets for social progress has created a vast 'milling about' in the application of national resources to social needs. It is particularly disturbing to note the effort being expended upon the transfer of technology from the public to the private sector with neither guidelines on national objectives nor incentives to apply the technology to such objectives. Therein lies the theme of this paper.

The stages of homogeneous interactions between technology and public policy will be defined and the ultimate state will be projected. The prerequisite to this stage — the establishment of national goals — will be examined, and a simple dynamic systems model proposed.

THE INTERACTIONS BETWEEN TECHNOLOGY & PUBLIC POLICY

It has been stated that the distinguishing feature of our time is technological development. The interactions of these developments and public policy can be classified in three stages:

I. The shaping of public policy by technological feasibility.

II. The curtailment of technology by public policy.

III. The utilization of technology in support of public policy.

The first stage can be considered to have begun with the industrial revolution. During this stage, the major choices among future national programs were largely technological rather than political. The feasibility of the automobile as a transportation means, for example, shaped the public policy for road-building, as did the feasibility of technically and economically viable commercial passenger aircraft generate a public policy for constructing airports and air traffic control networks. Without conscious attention to what was happening, these two developments have evolved into the key elements of our present national transportation system, making their attendant air and noise pollution problems and their warping influence on the shape of the cities doubly difficult to solve and causing a critical dependence upon foreign sources for their vast fossil fuel demands. Countless examples spring to mind wherein technical feasibility was equated to social desirability without much serious question. The technological successes (and excesses) of this stage created the serious social problems which set the scene for Stage II, which is now in effect.

This stage began to develop after World War II. The overlap of Stages I and II is illustrated by the irony of accelerating city freeway construction (Stage I) coincident with increasing public concern for "smog" in the cities (Stage II). While the first stage was characterized by a positive attitude toward technology, the second is characterized by a negative one. One cannot help but surmise if the pendulum has not swung too far. However, Toffler asserts:

> *At the same time it is undeniably true that we frequently apply new technology stupidly and selfishly. In our haste to milk technology for immediate economic advantage, we have turned our environment into a physical and social tinder-box, (Toffler, 1970, p. 429).*

Elsewhere in that same reference, Toffler has an excellent description of the mechanics of Stage II:

> *We can no longer afford to let such secondary social and cultural effects just happen. We must attempt to anticipate them in advance, estimating, to the degree possible, their nature, strength, and timing. Where these effects are likely to be seriously damaging, we must also be prepared to block the new technology. It's as simple as that. Technology cannot be permitted to rampage through the society, (Ibid, p. 438).*

These views are given a quasi-official stamp by the National Goals Research Staff (NGRS, 1970, p. 27):

> *But today there is an explicit challenge to the view that we can or should continue to encourage or permit the unfettered growth of our economy, population, technology, use of materials and energy, flow of new products, and even of our scientific knowledge.*

So we see the essential nature of Stage II as functionally negative. It is typified by the word "consumerism." The future in the near term is to be predicted by considering both the technological probabilities and also our projected success in overcoming obstacles which are socially or politically significant.

It must be kept clearly in mind that the discussion is about thwarting technology, not science. As stated by Michael Polyani (Shils, 1968, p. 9):

> *You can kill or mutilate the advance of science, you cannot shape it. For it can advance only by essentially unpredictable steps, pursuing problems of its own, and the practical benefits of these advances will be incidental and hence doubly unpredictable.*

It would be unfortunate in the reactivism of Stage II if confusion in terms resulted in efforts to deny the *acquisition* of knowledge (science), as well as its application (technology). The terms are often used interchangeably in the literature.

In any event, while this policy stage may control technology, it won't enlist it for the public good. For that, one must emerge from the cocoon of Stage II as the butterfly of Stage III.

Stage III, now just as evanescent on the horizon as a desert mirage, will be characterized by a conscious effort to harness technology positively in the public interest. Whereas technology initially shaped policy, in this ultimate stage public policy will shape technology — not negatively by amputating it, as in Stage II, but positively by encouraging its growth in areas applicable to social objectives. And it won't come by our anticipating the bad side effects of emerging technology and *preventing* their occurrence, but by our identifying long-range desirable social effects and *causing* them to happen.

A prerequisite to Stage III is the authoritative establishment of clearly defined and positively adopted future national goals and objectives.

THE CREATION OF NATIONAL GOALS & OBJECTIVES

Lederman (1971, p. 6) cites the following definitions by the Committee for Economic Development:

> *Goals are 'statements of highly desirable conditions toward which society should be directed,' while objectives are 'the stated purpose of an organization — or an individual — capable of planning and taking action to gain intended ends.' They are generally more limited and more specific than broad goals, and are frequently quantitative.*

Traditionally, our leaders have assured us of their concern for social progress with such broadly-phrased goals as the "New Deal" or the "Great Society"; but they generally have left us unburdened by specific objectives and the means of attaining them. However, the need for national goals and objectives has been recognized by past and present public and private groups and has resulted, predictably, in the establishment of commissions and staffs for the formulation of such goals and objectives. Their "goals" appear to be generated by one of the following methodologies:

1. The generation of a framework of national needs, and the examination of each independent of all others.

2. The projection of past trends as future goals.

3. The assessment of available technology applicable to current social trends.

The first methodology was applied by the Commission on National Goals, created by President Eisenhower in 1960. This commission established fifteen "areas of concern," which equated to goals. In 1961, a sixteenth concern, space was added to the list. These were:

1. Agriculture
2. Area Redevelopment
3. Consumer Expenditures
4. Education
5. Health
6. Housing
7. International Aid
8. Manpower Retraining
9. National Defense
10. Natural Resources
11. Private Plant & Equipment
12. Research & Development
13. Social Welfare
14. Transportation
15. Urban Development
16. Space

(NGRS, 1970).

These "goals" were not specific. The National Planning Association undertook the preparation of standards for each area of concern and in 1965 published the expected cost of meeting these standards during the 1970's. This undertaking suffered from a focus on immediate problems. As usually happens when emphasis is placed upon immediacy, by the time a response is applied the problem has either disappeared or, more likely, has escalated beyond the bounds of the solution. The notable exception was the space afterthought, which, in fact, became a highly specific national objective: to reach the moon. The accomplishment of the lunar landing in 1969 was due in no small part to its precise specification. All of these goals or concerns, however, suffer from a lack of clearly described relationships to each other.

Typical of the second approach, that of future projection based on past trends, is the work of Lederman and Windus (1971, p. 3-4). They examined federal budget trends in 12 "functional fields" largely encompassed by the 16 "areas of concern" previously mentioned. They projected these trends as the government programs of the future. Unfortunately, this approach may most closely fit the workings of the real world. As Lecht observes (1969, p. iii),

> *There is, first, the probability that, as individuals and as a nation, we will continue to spend money tomorrow for the same or similar purposes as we do today and did yesterday. Furthermore, for a considerable portion of additional resources, the allocation appears predetermined with a high degree of probability. Actually we have a scale of allocations, from those that can be predicted with great probability to that relatively small portion that are truly discretionary. (Ibid, p. 5).*

Lecht calls this the concept of pre-empted goals.

The Third approach, the assessment of available technology, is typified by the output of the National Goals Research Staff. This group was established as a staff within the White House by President Nixon in 1969. Its functions were:

> *. . .forecasting future developments and assessing the longer range consequences of present social trends. . . measuring the probable future impact of alternative courses of action, including measuring the degree to which change in one area would be likely to affect another. . . estimating the actual range of social choice — that is, what alternative sets of goals might be attainable, in light of the availability of resources and possible rates of progress. . . developing and monitoring social indicators that can reflect the present and future quality of American life, and the direction and rate of its change . . . summarizing, integrating, and correlating the results of related research activities being carried on within the various Federal agencies and by State and local governments and private organizations. (NGRS, 1970, p. 174).*

The NGRS 1970 report to the President contains a compendium of trends and projections, a summary of concerns in seven major social areas, and offers a "shopping bag" of alternative choices of action. The selection of options by the recipient of the report presumably would generate goals; specific objectives were not addressed. Nevertheless, the work of the National Goals Research Staff provides a valuable insight into the current problems of society in the United States.

In summary then, attempts to generate national goals since 1960 have been generally based upon one of the three methodologies previously mentioned, each typified by a given study. The first method, the independent examination of each national goal, has several shortcomings. First, it has a tendency to focus on immediate problems, thereby generating independent objectives; second, it lacks an integrative long-range approach to a broader goal. While the second approach

dooms our future to the political expendiencies of the past, the third generates a "goal" whenever an economically feasible technical reality can be matched to an identified social inadequacy.

Leonard Lecht's criticism of past attempts to establish national goals is highly applicable to these three techniques, including his own:

> *The activities described as the pursuit of national goals typically represents activities we select piece-meal as pragmatic responses to specific individual and national problems, activities we sometimes blunder into, rather than constituting programs consciously selected because they contribute to our society's goals. (Lecht, 1969, p. 4-5).*

He concludes that:

> *In the absence of a framework of information about the costs, benefits, manpower needs, and side effects of individual programs, which relates them to the overall objectives they may further or frustrate the choices implemented often create unanticipated problems that cancel out the anticipated benefits, or they reflect the options of narrowly based pressure groups and special interests.*

A SYSTEMS MODEL FOR TECHNOLOGY UTILIZATION IN SUPPORT OF PUBLIC POLICY

Concurrent with the efforts to create national goals and objectives described in Section III have been separate and unrelated attempts to foster the utilization of technology developed for public sector programs in private sector applications.

This was a specific mandate to the National Aeronautics and Space Administration in the very act which created it. In 1963, NASA had $2.5 million allotted for just this task. In 1962, implementing a recommendation of the White House Panel on Civilian Technology, the post of Assistant Secretary for Science and Technology was created in the Commerce Department to "encourage rapid diffusion of new technology" and to stimulate its industrial utilization. (Allison, Dec. 1963, p. 26) While these initial formal efforts were not distinctly successful (probably due as much as anything to the difficulty of measuring "success"), the recognition of the resource value of our public stockpile of technology caused a gradual increase in the scope of the transfer effort, notably in the Department of Defense.

However, the rate of technology transfer for use in the competitive market-place has increased. Without national goals and firm future objectives for guidance in technology utilization we will remain in Stage II. Counter-productive forces will remain at work, one to increase the utilization rate of technology and the other to prevent a technological "rampage through society."

Until we identify clearly and credibly national goals, specify succinctly objectives, and establish policies which encourage the coordinated utilization of technology in their achievement. Alvin Toffler's description of a society in the throes of accelerating technological change is portentious:

> *Acceleration produces a faster turnover of goals, a greater transience of purpose. Diversity or fragmentation leads to a relentless multiplication of goals. Caught in this churning, goal-cluttered environment, we stagger, future shocked, from crisis to crisis, pursuing a welter of conflicting and self-cancelling purposes. (Toffler, 1970, p. 471).*

To achieve maximum efficiency in the employment of technology for the public good is to achieve congruence between the goals of innovators, the users of technology, and those of the body politic. The author believes the possible seeds of Stage III may be contained in H.R. 10230,

a bill proposed by 25 members of the House of Representatives. While this bill purports to "establish a science and technology policy for the United States," it goes further in its implementation:

1. The Federal Government should maintain central policy planning elements in the executive branch which assist Federal agencies in (a) identifying public problems and objectives (b) mobilizing scientific and technological resources for essential national programs . . . (H. R. 10230, p. 21).

This sounds helpful. Presumably, goals are to be established in their own absolute right, not just based upon the probability of being achieved with an existing technology.

The bill proposes an "Office of Science and Technology," while it could more effectively offer an integration of the technology function with the objective-setting one. The author envisions an "Office of National Objectives and Technology Utilization," operating under the more broadly defined national goals generated by the executive and legislative branches of the Federal Government.

The operation of such an office would be as the control agent in this simple yet dynamic systems model:

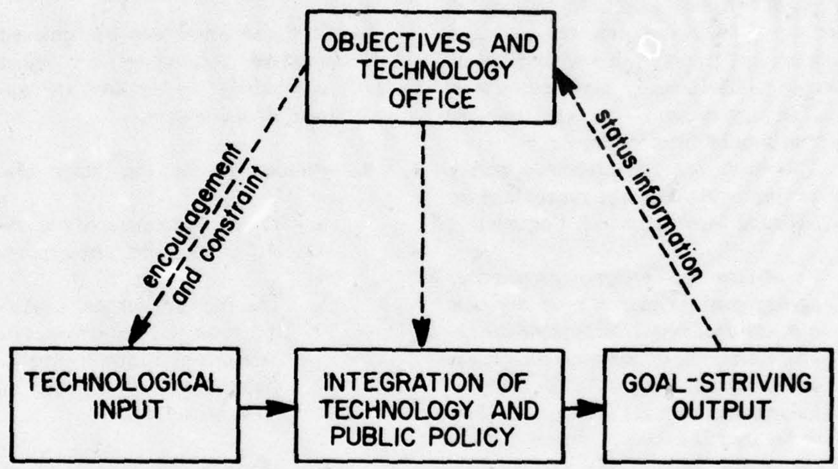

Figure 1. Functions of an "Office of National Objectives and Technology Utilization"

The proposed office would operate under the defined goals of the executive and legislative branches of the federal government. The office would assist in measuring and controlling achievement of objectives.

Such a system would contain objectives, a means of measurement of their achievement, and a method of control over the achievement process. Where existing technology could assist achieving objectives, industrial effort in this direction should be encouraged. This could best be done by recognizing and utilizing the self-interest motivations of the private sector, such as by providing tax breaks for recognized goal-directed technology utilization.

Where no technology exists to achieve a national objective, research and development requirements should be identified and federally funded. However, it should be recognized that the application of existing technology can be more efficient. Therefore, an effective information search system should be utilized prior to undertaking new research and development, to determine what relevant technology has already been developed; then, an aggressive technology transfer program should be encouraged.

The need for an integrated policy and technology body was recognized by the National Goals Research Committee:

> *As of now, no Government or other agency has the authority to appraise our national needs, determine an appropriately balanced national scientific program, and make the case for its support before the public, Congress, and the White House. Nor is there any agency with responsibilities, capability, and authority to order the internal and external priorities of science, to choose from among the rich selection of options new before the Nation, or to attempt to balance the future supply of scientists with anticipated demands. (NGRS, 1970).*

Hopefully, Stage III is not too far off.

CONCLUSIONS

From the foregoing discussion, it is concluded that:

1. We have evolved from a society hopefully seeking ways to utilize new technology into one wary of negative technological side-effects.

2. A higher stage can be achieved wherein technology can most compatibly be enlisted in support of social aims.

3. Prerequisite to this stage are:

   a. The establishment of national goals and objectives.

   b. The recognition and exploitation of the motivations of private enterprise to pursue technology in support of these objectives.

   c. The development of a means of measurement of their achievement.

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Chapter 2

TECHNOLOGY & ECONOMICS: PROBLEMS OR ANSWERS

by

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ABSTRACT

This paper postulates that an underlying cause of present energy and pollution problems is the tendency for the total costs of social actions to be hidden in the tax structure and in the degradation of the public environment. The relationship between social goals, economics, and technology is explored, and a scenario which illustrates the effects of hidden costs is described. The conclusion reached is that exposure of full costs will bring economic forces to bear toward a technological solution.

INTRODUCTION

Man is the center of the Universe. He was given dominion over the Earth. But he was not given an unlimited bounty; rather, he was placed in stewardship over a limited ecosystem lost in the cosmos. Only recently has the significance of this responsibility become apparent to him. The blue sky, the clear waters, the "boundless" resources are beginning to run short.

Man's commitment to progress, particularly in the United States, has been reflected in a goal of maximizing the physical product. He has pursued this goal relentlessly. The Gross National Product under man's stewardship has blossomed, but he has paid a price The question is has the result been worth the price? This involves answering the questions:

a. Has he attained what he wished to attain?

b. Could he attain the same goal more effectively?

c. What did attainment of this goal really cost?

The purpose of this paper is to explore how these questions might be pursued. It is considered that the answers lie in the definition of a set of social goals, in properly-directed technology and in a thorough economical treatment of the costs.

THE ROLE OF TECHNOLOGY AND ECONOMICS

Technology and economics have been blamed by a large portion of the public for the dilemma in which it finds itself. Hardin states, "The overall evidence seems clear. The chief reason for the environmental crisis is the sweeping transformation of productive technology since World War II. Productive technologies with intense impacts on the environment have displaced less destructive products." (Hardin, 1972, p. 177) Steward Udall says, "In post-war America technology was holy writ. No problem was so complex that it couldn't be solved through more ingenious technology." (1974, p. 23) Even Drucker looks to a new generation which differentiates between economic values and human values . (1971, p. 70) The author maintains that neither economics nor technology is the principle cause of the dilemma; rather, it is the direction in which they have been aimed or allowed to develop that is the cause. Specific goals must be established before economics or technology can be used as tools to achieve such goals.

Today, any ten people polled on what direction they think that the United States should be headed, would likely define ten different goals ranging from a position of material superiority to a unified world government. Even the presidents of the United States had widely divergent views. Several aided in the draft of the Declaration of Independence which saw the government as the guardian of the individual, ". . . to ensure these rights, governments have been instituted among men." John F. Kennedy placed the emphasis on society, "Ask not what your country can do for you, but rather, what can you do for your country."

Dasman contends that:

> *It is not surprising then that those areas of conservation (technology) which produce a profit are readily received whereas those that cost money without compensatory income lag far behind. (1968, p. 152)*

One needs to define what constitutes "compensatory income" to evaluate the validity of Dasman's assertion. Obviously technology does not progress without a goal toward which progress can be measured. If misdirected it can create monsters, but properly channeled toward a desired goal, technology will define a set of optimal actions for attaining a goal.

Omar Khayyam asked once "What? Without asking, hither hurried whence? And without asking, wither hurried hence?" (Khayyam, 1942, p. 29) Galbraith succintly summarized the situation:

> *One of the amiable idiosyncrosies of man is his ability to expend a great deal of effort without much inquiry as to why . . . Still, it might be useful on occasion, to ask about the goals of any costly effort, and such, I am persuaded is the case with economic development. Development implies movement toward some result. What should be that result? There is always the danger that in the absence of such specification, we will triumphly achieve some unwanted end." (Galbraith, 1971)*

Analysis of Alternatives

In addition to specifying the desired goal, we also determine how that goal is to be achieved. It is maintained that this cannot be effectively done unless the true costs of the available alternatives can be examined. One would expect that the cost of an item is reflected by the price that one must pay in the market place. However, portions of the cost which are passed indirectly to society become hidden, or in the words of the economists, "externalized." The cost of pollution is a current example. Garvey estimates that the costs connected with air pollution only run to billions of dollars per year. (1972, p. 86) These costs must be "internalized" if alternatives are to be compared. Initially, all costs were external. If Adam wanted an apple, he had only to pluck it from the tree. Free? Hardly, but the costs weren't immediately evident when he made his decision. Gradually, material and labor costs became internalized. Then more indirect costs, such as education of the work force, costs of industrial accidents, and employee health and well-being, were added to the product cost.

Cost may be defined as what one gives up for the sake of a particular course of action. Expenditures for clean air and water and the depletion of irreplaceable natural resources are a logical extension of this definition. When total price becomes apparent, the law of supply and demand will bring a balanced consumption. As matters now exist, the total price is hidden, and the lower market price causes consumption which is economically out of proportion. (See Figure 1)

A Tragedy on the Commons

Consider the scenario that Hardin describes as a "Tragedy on the Commons." (1972, p. 254) The tragedy develops in this way. Picture a pasture open to all. Each herdsman tries to keep as many cattle as possible on this Commons. As with any scarce resource, there comes a point of diminishing returns, a point where an additional cow on the Commons provides an overall negative marginal value. The individual herdsman, however, receives the full gain from an additional cow when the loss is spread over all of the herdsmen. Therefore, the only sensible thing to do is to add as many cows as he can. This conclusion is reached by every rational herdsman in in the group. And therein lies the tragedy. Each man is locked into a system

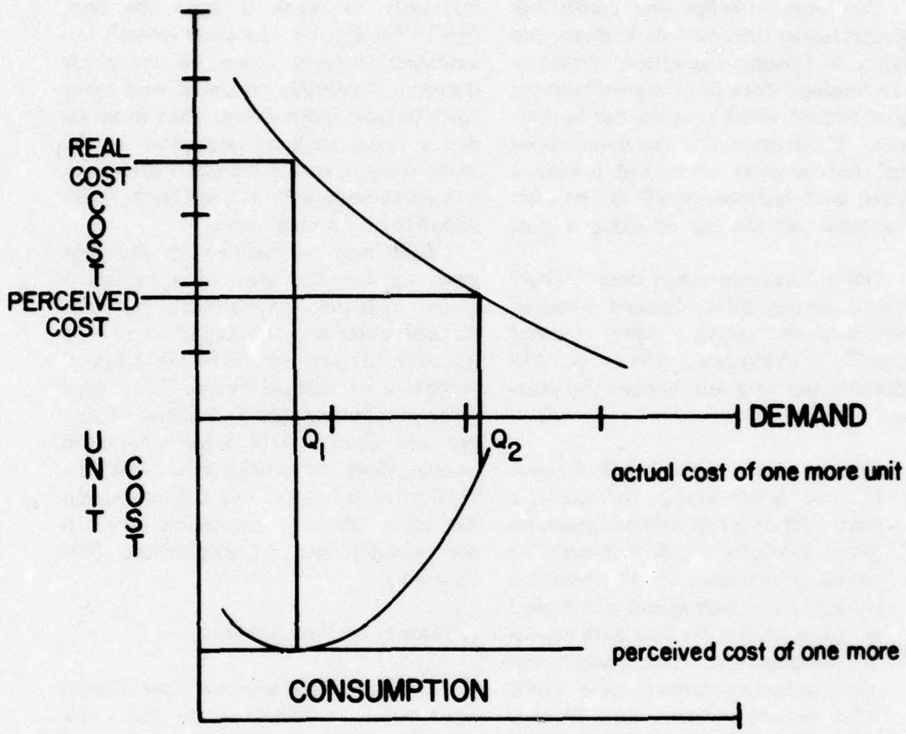

Figure 1. The Difference Between Perceived and Real Cost

Were full costs known, the market would consume Q leading to efficient operation on the production function. However, under the influence of the perceived price, the market consume Q at a much higher marginal (and total) cost. (Source: Nicholson, 1972, p. 220)

which compels him to increase his herd without limit in a world that is limited. To continue the analogy beyond where Hardin left off, consider that some perceptive herdsman perceives the Common decline and reasons with his fellow herdsman that they should band together and maintain the Commons, and use a per-animal tax to apportion the expense. The total cost system acts to bring economic balance back to the Commons.

Now let time pass. The pasture taxes become intermingled with sales taxes, income taxes, etc., and cease to be recognized as a reflection of the cost of maintaining the Commons. Even though the same high cost of an additional cow is extracted from the herdsman, the herdsman does not realize the connection. Thus, the perceived cost of adding another cow to the Commons makes the addition of that extra cow appear as economically sound. Taxes increase, the herdsman's income decreases; however, in his mind it is not due to the addition of that extra cow, but rather to the cost of "big government."

To maintain his income, the herdsman increases the price of beef to the public. The dollar average utility of beef to the citizenry declines and less beef is consumed, threatening the beef industry. Continued expansion is viewed as a necessary good by the community; therefore, the government subsidizes the beef industry. Higher taxes ensue, but the "price" of beef declines and consumption increases.

The beef industry grows; there are more cows on the Commons. Moreover, there is a limit to what correction can be made to the abuse of overgrazing. The Commons has truly started to deteriorate. The ground is worn bare, and an "energy" shortage develops. Cow dung is everywhere, polluting the environment. Each person acts to maximize his own utility and in so doing actually diminishes it. The taxes are considerable but at least food is cheap.

The irony of the above scenario is not that somebody is making an extraordinary profit at the expense of someone else, but rather that everybody is suffering due to inefficient operation of the Commons. The herdsman wastes his resources, and the resultant waste products pollute his environment.

WASTE

If the situation described above seems far fetched, consider the case of the American automobile. It is one of the most inefficient machines imaginable, particularly when operated with the national average of 1.3 people per carload. In response to what was considered to be a rational cost/demand tradeoff, industry turned to the production of smaller wars. Yet the public didn't buy them. Why? Because the true cost was hidden. The price of gasoline was obscured by price controls and industry subsidies in the form of depletion allowances, etc. The costs of more streets and parking, and increased pollution are similarly hidden, or at least allowed to accumulate in a degraded environment.

In 1970, the United States used the equivalent of over 29.7 million barrels of oil per day. Only 50 per cent of this was purposely utilized. The other half was wasted due to inefficiencies of utilization and transmission. By 1980, the consumption of energy is expected to increase by 45 per cent, but the overall efficiency of utilization is expected to fall to only 46 per cent. (Joint Committee on Atomic Energy, 1973, p. 11) (See Figures 2 and 3.)

Electricity furnishes only 35 per cent of the energy used in its generation. Garvey estimates that the total efficiency of electrical power, from the coal mine to the baking of a cake is in the order of 14 per cent. (1972, p. 52) As Rodgers points out, the true cost of electricity is hidden by such measures as New York's 8 billion dollar subsidy program to the electrical power generating industry. (1972, p. 245) Moreover, these wastes and inefficiencies are a major part of the pollution problem. Estimates of energy-associated environmental damages run to tens of billions of dollars per year; for

the most part, they are externalized costs. As seen in the case of the Commons, the costs of wastes are passed to all of us, but because they are not readily apparent, the laws of economics cannot function to keep balance in the market place; consequently, production is driven to inefficiency. Admittedly, some waste is inevitable. The second law of thermodynamics will not be stayed by wishful thinking or even technology. Still, a large part of the waste must be charged to avoidable inefficiencies.

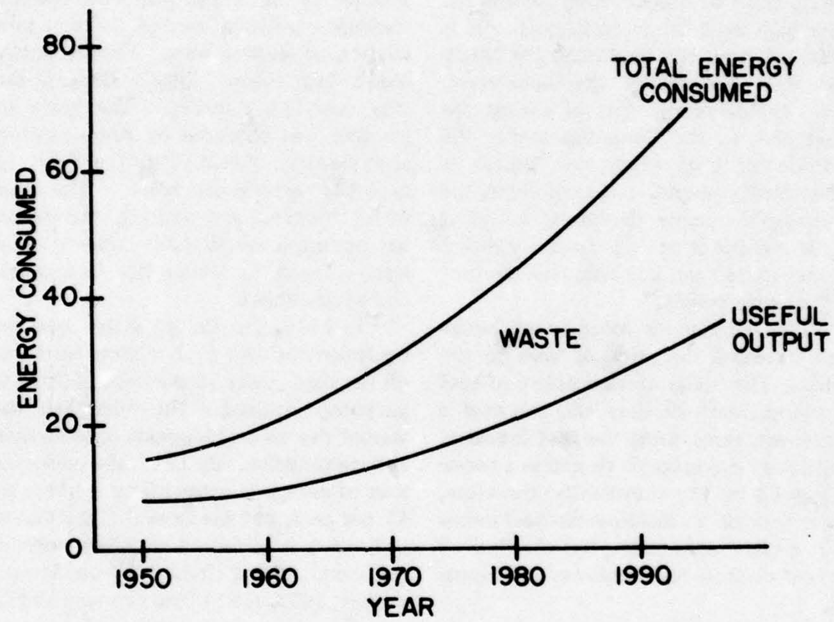

Figure 2. Useful Output in Relation to Total Energy Consumed

The figure shows that "waste", the difference between total energy consumed and useful output, will continue to increase in the future. Source: Joint Committee on Atomic Energy, 1972, foldout "G").

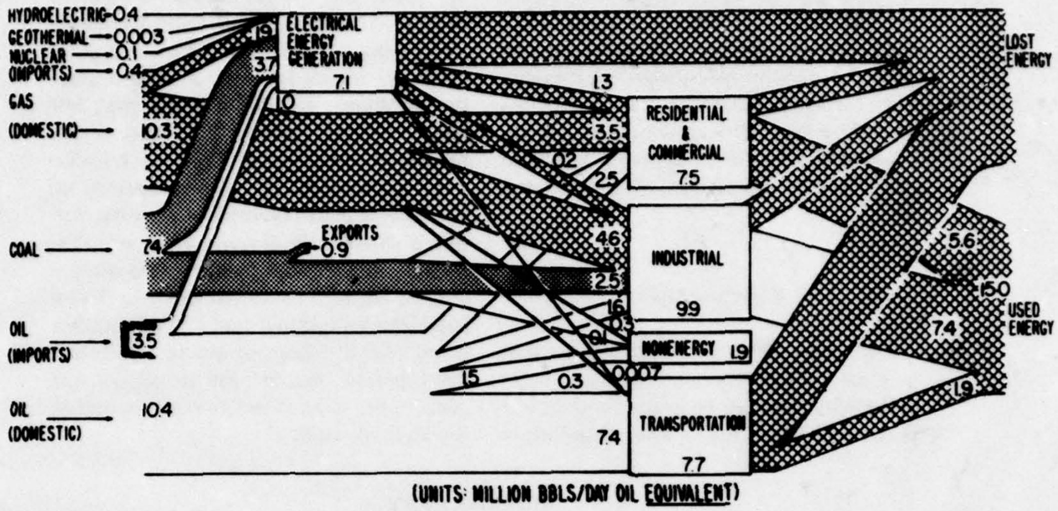

Figure 3. Use and Allocation of Different Forms of Energy in 1970.

The figure shows that lost energy is almost as large as used energy (14.7% and 15.0% respectively). Electrical energy generation and transportation are the two largest components of lost energy. Source: Joint Committee on Atomic Energy, 1972, foldout "C").

INTEGRATING THE MEANS AND THE ENDS

One acute observer saw to the heart of the problem. "We have met the enemy and he is us", observed Pogo. As tools of man's purpose, technology and economics can only follow as directed. If directed to maximize monitary profits, economics will lead to this goal. If directed to maximize human utility (and this utility is defined), given the scent, economics will lead the way. Similarly, when we wanted to walk on the moon, technology took us there. Should we direct technology to the task of reducing waste and increasing efficiency, such goals can be accomplished. For example, such processes as magnetohydrodynamic power generation systems can increase efficiencies up to 60 per cent. Use of ultra-high voltage transmission lines and D. C. power transmission can significantly reduce transmission losses. (Rodgers 1972, p. 256)

But the full costs of power generation must be determined so that the economics of such technology can be evaluated. Growth, both in terms of population and standard of living is going to require more energy, and, as previously pointed out, the more energy that is used, the more is wasted. An increase of 59 per cent in efficiency would allow a 50 per cent increase in energy available without any increase in total consumption. Technology can widen the range of

society's options as well. The leverage of technology can permit increasing efficiencies and greater capabilities. To the extent that it is necessary to expend additional energy resources on technology in order to develop new power sources and more efficient processes, total conservation may be counterproductive. Again, examination of full costs permits a valid and efficient evaluation of the alternatives.

CONCLUSION

It is the conclusion of this paper that lack of proper direction for economics and technology has been the cause of our current dilemma in the area of pollution and energy. This has been brought on, in part, by a system of disguised costs which has made the "worst appear the better cause." The pressures of today's realities are forcing the selection of an end goal; however, for us to make a valid evaluation of alternatives to reach this goal, full costs must be made visible and be reflected in the market. The most viable way to accomplish internalization of these costs is to eliminate a tax structure which shields actual costs from scrutiny and to require that industry absorb the cost of damage to the ecosystem. When goals are established and options understood, the direction of our technological development can be set to attain our goals in the most effective manner, and at the least eco-cost.

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Chapter 3

TECHNOLOGY: NO POLICY FOR GIANTS

by

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ABSTRACT

Technology is growing, subdividing, causing persistent change and appearing as a momentous giant, moving where it chooses. Public policy on science and technology is pluralistic and fragmented. Information on activity, status, and control are vitally needed to provide for more effective management of current technology. Through methods of management information systems reporting techniques, perspectives and solutions to the problem are highlighted in the following essay.

INTRODUCTION

Technology refers to the systematic application of scientific, engineering, administrative, and other bodies of knowledge to the accomplishment of practical tasks and problem solving. Among other things, technology is used to detect illness, harvest cotton, wage war, supervise and transport people, and control birth.

From an expanding state of knowledge, technology transfer extracts applications to produce activities and commodities that were previously unattainable or undiscovered. As a consequence, the pace of technological advance induces fundamental and persistent change. Historians, such as Elting Morison (1974, p. 171), view the changes with some alarm.

> *The technological systems we construct move, self evidently, toward increasing change. Man, in the past, has been differentiated from all other creatures by a remarkable capacity to accommodate. He has moved, in large part by taking thought, from the cave to condominium, from the foot pace to the speed of sound, from hard labor to services supplied by a whole structure of invisible hands. A great question now is whether he can continue this amazing power of accommodation in a period when more and more things in his environment change more and more rapidly and when the process of change produces not only increased goods and services, but environmental pollution and increased confusion. At what point will he simply break down as fuses blow in an overloaded system?*

Public policy regarding technology must address itself to two issues — the destination toward which change carries us as well as the speed of the journey. The U. S. National Commission on Technology made this conclusion with regard to attainment of national goals (Bowen, 1966, p. 51):

> *Ours, like most modern societies, is becoming 'future-oriented'. We realize that we have to plan ahead. We have to anticipate social change. We need to assess its consequences. We have to decide what policies are necessary to facilitate, or inhibit, possible changes.*
>
> *Increasingly, technology makes it possible for societies to 'invent the future'. Given the great resources of this country, we can decide what kinds of future we want and work for it. We can spell out our national goals and seek to meet them within the framework of our capacities.*

Technology is such an important resource that it must be managed carefully. Managers must have complete, accurate, and timely information to make sound decisions. Of course, the availability of information does not in itself guarantee intelligent use; but without information, a manager is at a decidedly serious disadvantage.

A management information system is defined as any information system that provides a manager with information for a given period on the activity, current status, and control of the system for which he is responsible. The remainder of

this paper is structured as a management information system, providing samples of the activity, status, and control of current technology.

AWAKEN THE SLEEPING GIANT: AN ACTIVITY REPORT

Knowledge Explosion

Knowledge is the fuel of technology. If we trace the history of books and use this as an activity barometer of knowledge, the following estimates prevail. (Toffler, 1970, pp. 30-31)

Prior to 1500 A.D., estimates indicate that Europe was reproducing books at the rate of 1,000 titles per year. At that rate, it took a full century to produce a library of 100,000 titles. By 1950, Europe was producing 120,000 titles a year — what formerly took a century now took ten months. By 1960, a 15th century's work could be completed in seven and one-half months. By the mid-sixties, books on a world scale approached 1,000 titles per day. Today, the United States government generates 100,000 reports each year plus 450,000 articles, books, and papers. On a worldwide basis, scientific and technical literature mount at a rate of 60,000,000 pages a year.

There is no reason to believe that each new unit of literature represents a completely new source of knowledge. Researchers and practitioners are often found to independently make the same discoveries. But, even a discount for overlap will not take the edge from the fact that the frontiers of knowledge are being mined at a tremendous rate.

Furthermore, there is reason to believe that the rate is still rising. The number of scientific journals and articles is doubling about every 15 years and according to biochemist Philip Siekevitz. (Ibid, p. 31):

> *What has been learned in the last three decades about the nature of living beings dwarfs in extent of knowledge any comparable period of scientific discovery in the history of mankind.*

With knowledge as the fuel of technology, the flow of this fuel can be depicted in the following chart:

Frontier of the Unknown

↓

Knowledge

↓

Applications

↓

Impact

↓

Obsolescence

Figure 1. Knowledge Flow Cycle

The flow of knowledge from first discovery through practical application to obsolescence is shown. This is a never ending cycle where the application, knowledge and impact are often the fuel for the discovery of additional knowledge.

Applications Acceleration

An expanding state of knowledge permits the production of new commodities and increases the types and kinds of services provided. Industrial growth rates range from 5 to 10 per cent in most industrial nations. During the 1960 to 1968 period, United States production grew at the rate of 4.5 per cent.

A growth rate of 5 per cent implies a doubling of the total output of goods approximately every fifteen years. Within a seventy-five year lifetime, five doublings could take place. By the time an indivi-

dual reaches old age, the society around him will be producing thirty-two times as much as when he was born. (Ibid, p. 24)

Stanford Research Institute studied the span of time between the first commercial appearance of a new electrical appliance and the time manufacturing reaches peak production of the item. The average span of time before 1920 was thirty-four years. Between 1939 and 1959, the span was reduced to eight years. (Ibid, p. 28) Other investigators have shown a similar reduction in the time between discovery of ideas and the first application.

The stepped up pace of discovery, exploitation and diffusion in turn accelerates the whole cycle still further. New machines and techniques are not only products, but a source of fresh ideas. These new ideas extend to every facet of our existence. Men on the moon, supersonic transports, war by remotely piloted vehicles, food production, energy, leisure time, computers, city planning, research and development are but a few examples of technology's impact. Hardly an area of life is left untouched by recent technology and innovation.

Impact

Economic research has ascribed 40 per cent or more of the growth in industrial output as a direct result of technological progress. (Nicholson, 1972, p.216) Progress has blessed parts of the world with an unprecedented standard of living and supply of per capita goods. And yet, so-called "progress" has resulted in pollution, waste and shortages of certain resources. Complaints are heard that technology is bringing power to the technologically elite and that culture gap and future shock are setting in.

Morison (1974, p. 172) describes possible impact as follows:

> *Technical systems proceed toward generality and abstraction — numbers, models, print-outs, credit cards, experience converted to pictures, and so forth. The power to abstract has been a principal resource for man in the struggle from primal mud to high-rise. But still much of his experience has remained literal and concrete — face to face, reaping where one sowed, building with one's own hands, judging by the fruits thereof. The question here is how much abstraction can man stand, how much removal from first causes, how much action at a distance, how much translation of personal experience into attenuating resemblances or symbols, before he gets beside himself among the shadows?*

PORTRAIT OF A GIANT: A STATUS REPORT

Economic Demand for Technology

The urge for new technology is tremendous. A text on *Economics of the Firm*, (Thompson, 1973, p. 201) states that "Technical innovation and virtuosity is a weapon of rivalry which pervades nearly every industry."

Some firms are more financially able than others to engage in invention and innovation. Hence, they place strong emphasis on research and development activities and tend to be technologically progressive. Implicit in a firm's search for improved production techniques is the hope that successful research and development activities will increase productive efficiency or provide new ideas; this in turn will give the firm a cost or marketing advantage and ultimately allow for higher profitability.

Managers hedge future survival and protect their competitive position by participation in the stream of innovation, even if they are uncertain where it leads and cannot predict a positive payoff. Additionally, innovation is often viewed as a requisite for maintaining the quality and and morale of technical and engineering staff (equating a progressive image with the attraction of high-calibre personnel).

The economic picture is summarized

by Thompson (1973, p. 202):

> *The point here is that personality and organizational consideraations prevailing inside the firm combine with economic forces from outside to virtually compel an enterprise to participate in or even initiate major innovation programs.*

It would be wrong to conclude that profit-maximizing firms provide the only demand for technology. Cities and nations provide services such as education, national defense, and voting opportunities. With these services come the social, cultural and economic factors that influence the adoption of problem solving techniques and increasing technology.

There is good reason to claim that the very act of identifying a problem kindles an innovative flame. This can be true on any organizational scale down to the individual person; some quests are merely better financed or more skillfully executed than others.

Summary status: There is a giant demand for technology.

Technology Flow Status

The fountains of technology begin with research at the frontiers of current knowledge and experience. Explorations are often directed and propelled by a search for solutions to specific problems while other research is open ended and undirected, free to explore knowledge for the sake of knowledge.

When an idea shows promise of application to a practical purpose it goes through a development process wherein further knowledge is gained in a learn-by-doing situation. The combined inputs of research and development (R&D) build a potential pressure that permits technology to flow. In fiscal year 1973, the federal government funded seventeen billion dollars of R&D. While about one billion dollars were spent on the collection, dissemination and processing of documentation, only forty-three million were spent to stimulate the secondary uses of ideas and inventions. (National Academy of Engineering, 1974, p. 16) In addition to federal expenditures, universities and private companies contributed their independent research and development resources.

The flow of technology is represented by the chart in Figure 2. Some of the new ideas flow freely toward useful applications and result in goods and services available to mankind. Yet, criticisms have been leveled at each of the three main features of technology flow: inputs, outputs, and flow channels. The R&D inputs have been criticized, at various times, as being too small, too large, or misdirected. At this point, we have little in the way of standards to guide our judgments. The applications of technology (output) seem most criticized for their direction or disproportionate benefits for the few.

Recent interest has been mounting for thorough analysis of flow channels, and has given rise to the concept of technology transfer.[1] Investigators are interested in tracing the technology pipelines and discovering the valves, rating the capacity, flow rate, and resistance and discovering the leaks.

A research paper by T. J. Allen (1966, p. 1) states that the existing channels for communications within and between scientific and technical communities are not performing as well as desired. He notes an astounding lack of understanding of the way in which the channels actually function.

The flow of technology, as measured by adoption by firms and industries, displays a wide variety of rates. Some innovations languish in oblivion for long periods and then are adopted rapidly,

[1]Technology transfer is defined as ("*a purposive, conscious effort to move technical devices, materials, methods, and/or information from the point of discovery or development to new users.*" (Creighton, 1972, p. 2)

others never mount a serious challenge to displace current operations, and still others come quickly into general use.

One assessment of the dormant class of ideas is given by the head of Product Development Consultant. (Rockett, July 1967, p. 33)

> *Nobody knows for sure how many good technical ideas lie fallow for every one that is a commercial success. The real number is unimportant. What counts is that mechanisms be found to bring a return on investment represented by this vast wasteland of technology . . . Selling these dormant ideas, or buying some yourself is an up and coming route to corporate growth.*

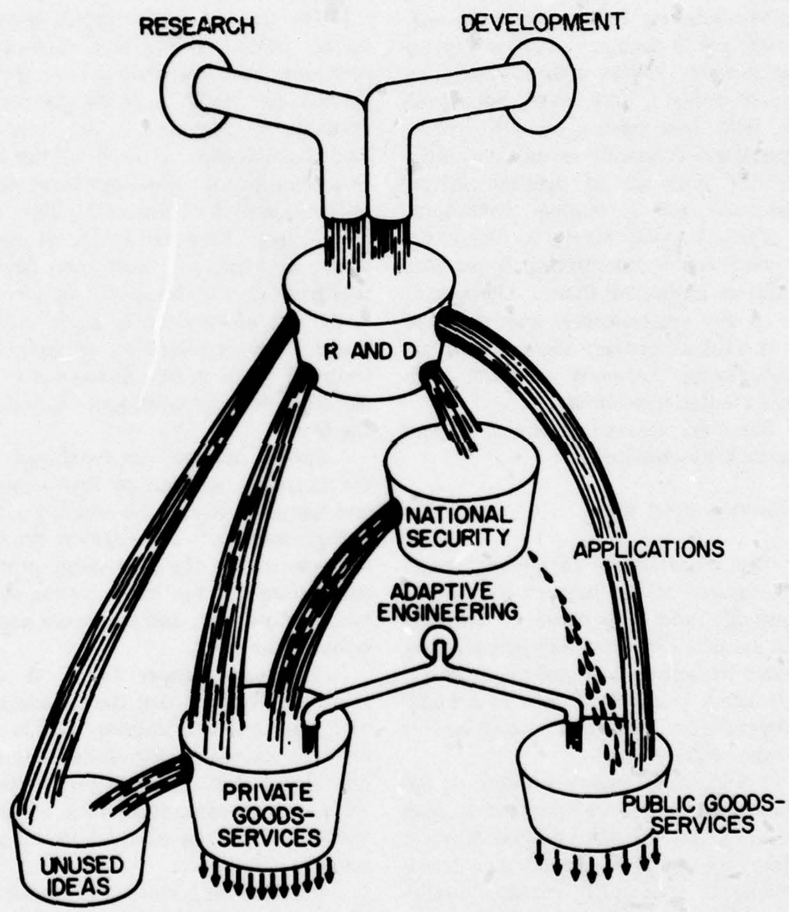

Figure 2. Technology Flow Chart

The technology flow has as its input research discoveries and development adaption of technological concepts and ideas. This generates a storehouse of R&D technology that flows to several sectors. The ultimate good of the R&D effort is new and expanded goods and services for both the public and private sector of the economy.

Widespread attention is being focused on technology diffusion, information dissemination, and knowledge linkers.[2] The research and experiences in these areas, just as with other technologies, bring promise of better flow for technology in general. Effective technology transfer could become at once both a relief for technological constipation and a network for integrating and directing technology toward purposive ends.

A Giant Under the Microscope

The broader and deeper society's technical capability, the greater is the technological imperative to subdivide activity so that the full contribution of each specialized bit of knowledge can be gained. Thus, a technology explosion starts with a single problem. The problem is studied and found to have structure. The structure may be divided and each part provides a new subject for study. This subdivision process is like a tree diagram describing some i^{th} problem in the world (see Figure 3). Notice that there is a geometric rate of expansion and that many other problems will be treated similarly. The branches of one problem tree may graft with branches of another problem tree. The overall result is an interdependent maze of combinational relationships that boggles the mind. This infinite fragmentation process makes it very difficult to track technology or to bound its consequences.

The complexity and pace of our giant seem to cleave the world into two parts: a community that understands science, copes with complexity and likes a fast and changing pace; another that is perplexed by science, prefers a relaxed pace and enjoys simplicity.

The former community is small in proportion to the latter but has a tremendous base for power; furthermore, the scientific community may appear elite to the other community and has a constant demand for higher skilled manpower to work on the growing branches of problem trees. This division provides the scenario for cultural lag and future shock.

With each increment of efficiency in technology transfer there is an accelerated pace for change in our world. As the giant picks up speed, it also becomes increasingly important that we know its direction. It appears that society has something big by the tail. What will be done with it? The immediate inclination is to ask the person in charge.

Who is in Charge?

The United States has no focal point of authority for science and technology. In the book *Brain Bank of America* (1975, p. 14), Boffey expresses:

> *It has long been acknowledged that the United States has no single science policy and no central scientific institution. Rather, it has a pluralistic system in which science policy is set by a multitude of public bodies and private organizations that operate on different levels and pursue different ends.*

It is evident from both the activity and status reports that the technology system needs some managing influence. Hence, proceed directly to the control report.

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[2]Technology diffusion refers to the historic unplanned movement of information from one user to another without a focused effort for active transfer; information dissemination implies a planned effort. Knowledge linkers are individuals who operate within an organization and provide the mechanism which couples the source of knowledge with the eventual utilization of this knowledge.

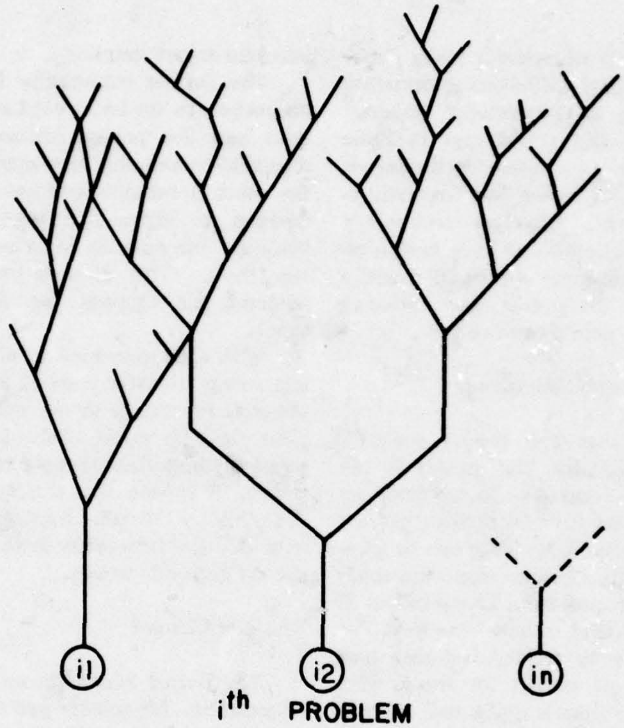

Figure 3. Problem Tree

Described is the subdivision process which occurs as each aspect of a problem is focused on, resulting in a geometric rate of expansion. The branches of one problem tree may graft with the branches of another tree in an interconnected maze. This infinite fragmentation makes it very difficult to track technology or bound its consequences.

DOMESTICATING THE GIANT: A CONTROL REPORT

Basis for Control

A complete control report cannot be presented for lack of essential information about the technology system. The following elements are lacking:

1. Identification of responsibility centers
2. System objectives
3. A budget or standards of production for the period

A review of the missing management control elements in in order. For the scope of this report, only a resume of procedures and alternatives will be presented.

Responsibility Accounting

The establishment of leadership and a public policy for science and technology, with all their various subdivisions, is no simple task. The persistent introduction of more advanced technology requires an organization with mechanisms to handle change and to cope with unscheduled development and contingencies. Shortcomings in a technologically sophisticated process are virtually intolerable, while correction time may be lengthy, expense costly, and scars on reputation long in healing. While acts of God may be excused, people who invent the future will be held responsible for it.

Many potential leaders consider the complex production of technology from the point of view of a few factors with which they are familiar and have skills in controlling. This kind of leadership pushes those few factors to the extreme, until diminishing returns prove that they are no longer required. Then, new leadership and new factors come to the forefront.

Ideal leadership would come from a "man for all seasons", using balanced, symmetrical, holistic approaches. Placed at his disposal would be tools that would help define objectives, assess alternatives and deal rationally with complex technical, political, economic, and social pressures that impinge on his task.

Systems analysis may be one such tool. Intended to overcome the piecemeal fragmentation of other more specialized approaches, the systems approach provides a language which talks of total embrace. Systems analysis would still require some development for use in managing technology. It is still an imprecise tool for dealing with the rather nonquantifiable factors of public policy. For these situations, it has popularly been rated as "paralysis by analysis". (Hoos, 1972, p. 25)

Objective and Standards of Production

For lack of a better starting point, the United States Planning-Programming-Budgeting System has listed the following general goals:

1. Identify our national goals with precision and on a continuing basis.

2. Choose from among these goals the ones that are most urgent.

3. Search for alternative means for reaching those goals most effectively at least cost.

4. Inform ourselves not merely on next year's costs, but on subsequent years' costs of our programs.

5. Measure the performance of our programs to insure a dollar's worth of service for each dollar spent.

The crucial questions are how and who should decide the objectives and standards to be used. Should we leave it to the scientists? Where would their interests take us? Could we leave it to the laymen? How well do they understand the problems? Morison (1974, p. 171) asks a similar question:

> *How can the jobs, the machines and the technical systems be designed to fit not so much the claims of production as the requirements of human beings?*

He then proposes a method with which we have some familiarity.

> *The concern for the particular case in the creation of the common law was equalled by the interest to proceed through a series of cases toward generality. Accumulating decisions, given increasing shape by the force of precedent, becomes a sort of controlling synthesis, an accepted regulation for recurring human actions that were similar, if not in detail, in kind.* Ibid, p. 177)

This process is meant to be sensitive

to every person's claim and yet provide some continuity and consistency for establishing norms. Briefly, the steps would proceed as follows:

1. Designate a selected technical problem.

2. Select a small group of engineers, scientists, government officials and wisemen to formulate a case (a file of trial briefs).

3. Conduct a hearing where all interested parties have a claim to be heard.

4. Formulate a final case with proposed alternatives supported by full explanations.

5. Place the issue before the people of the jurisdiction involved at voting time.

Such exercises, repeated at various places, would, in time, produce a considerable body of informed opinion that could be collected and codified as general principles governing the applications of science and technology.

Morison's proposed process of common technology, if it could be kept fluid, has a structure which includes goal direction, balance, symmetry, and integration — all of the elements which are so badly needed for domesticating the fragmented technological giant.

CONCLUSIONS

1. The management information systems approach, which consists of the activity, status, and control reports, is a useful method for problem exposition.

2. Technology has a vast capability for solving problems, but its fast pace and explosive fragmentation give it giant proportion and make it difficult to manage.

3. Technology transfer mechanisms provide a network that can bind the system together as well as provide for an efficient flow of technology.

4. Current public policy for science and technology is fragmented and devoid of effective responsibility centers and national objectives.

5. Systems analysis, common technology, or other balanced and holistic approaches should be developed to help integrate and guide our technology toward purposive benefits for mankind.

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Chapter 4

INTERNATIONAL TECHNOLOGY TRANSFER: RAMIFICATIONS CONCERNING COMMUNIST BLOC NATIONS

by

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ABSTRACT

The complexity of national and international facets of technology transfer — including military security, impact on world markets and economics, ideological image, and resultant human and social impacts — are discussed with a view toward public formulation. The transfer of technology related to development of productive capacity and computers within the People's Republic of China, and the paucity of factual information, developing trends, and future studies of technology transfer in the USSR are used to illustrate the relationships of these facets. The implicit exhortation of this survey is that in all policy formulation procedures consideration of all facets be assumed, particularly those relating to human and social impacts.

INTRODUCTION

Charles E. Hutchinson of the U.S. Air Force Office of Scientific Research quotes Gabriel Almond as contending that "The United States and the West must either lead in the process of modernizing the underdeveloped areas, or by default, contribute to a kind of world in which our institutions and values cannot survive." (Hutchison, 1966, p. iv.)

From 1950 through 1964, the United States enjoyed the dominant position as the Free World's supplier of military equipment. Today, this position is being challenged by nations (allied to the United States) whose emerging status is making review of U.S. methods and policies imperative. (Catledge, 1969, p. 179.) Our world market position is clearly being challenged.

Dr. Hans Mark, director of the National Aeronautics and Space Administration's Ames Research Center, is quoted by Richard O'Lone as having testified to a Senate subcommittee that, "A real loss in the capability of the U.S. to produce new technology for its own exploitation or for sale abroad as a product could be a major blow to our economic strength." (O'Lone, 1973, p. 83.) This raises the question of whether U.S. policy on "control of high-technology exports" to the USSR, China, and other communist nations should be made less rigid, and for what quid pro quo's? (Wolf, 1974, p. 5.)

The foregoing concerns echo:

> . . . *the thinking of a generation of American leaders who have invested substantial resources and other efforts to improve the conditions of life in deficit areas in the hope that economic advance would contribute to political stabilization and create the soil in which democratic institutions might take root* . . . (Hutchinson, 1966, p. iv.)

The decade since Hutchinson's expression of concern has but elaborated the dilemma of technology transfer and its complex ramifications. Many prominent Americans are still endeavoring to understand and reach an optimum solution for such complex problems as the world welfare and developing countries, maintenance of world image by technology transfer, protection of the U.S. share of the world markets, maintenance of the long run balance of payments, and national security protection. A most sensitive facet of these considerations remains the determination of propitious policies directed toward technology transfer with communist bloc nations.

OBJECTIVES

The principal objectives of this treatise shall encompass elucidation of significant facets of technology transfer with the major communist bloc nations — the USSR (Union of Soviet Socialist Republic) and the PRC (People's Republic of China), selected interrelated facets of technology transfer with and among other nations, and a description of some effects of our national policy in these matters. This presentation is not intended to be the springboard of a new and drastic revision of public policy or opinion, but rather an illumination of the

complex interrelationships of technology development and deliberate transfer, economic impacts, and national policy formulation.

TECHNOLOGY TRANSFER: GENERAL

Kranzberg states:

The transfer of technology is usually thought of as an imitative process. An underdeveloped nation imports the techniques and tools of more industrially advanced countries; or, within a developed nation, one sector of the economy simply adopts a manufacturing process found useful in another; or, within an industry, a firm copies the products and methods of its competitors. These would seem to be simple cases of imitation, were it not that imitation itself is a most complex matter.

If we are to understand the process of technological diffusion, we must regard technology as a cultural, social psychological, and political process as well as the imitation of artifacts. (Kranzberg, 1966, pp. 37-38.)

In addressing the subject of technology transfer, the human impact of innovation should not be overlooked, whether the change be educational, sociological, or technological, for each induces further change in the others. One author contends that "All types of change are disruptive of traditional culture patterns, but technological change is perhaps most disruptive of all." (Ibid., p. 37.) The concomitant need for new or higher skill levels places a near term demand on educational endeavors; and what force or impact, such as education, has as long-range an effect upon a nation's sociological and even political climate?

The impact of technological change can result in fear, high emotion, and near hysteria resulting from partial understanding. Are we not individually, and as a nation, led toward decisions and policies out of these motivations?

The sad historical fact is that those who have had a major voice in determining how technology is to be used in our society have not always been sensitive to the needs of those whose lives were surely going to be affected. (Tribus, 1971, p. 27.)

This impact of education so underlies the entire spectrum of technology innovation and transfer as to make one wonder which is the driving motivator. Skilled and flexible labor seem to operate within processes which create both the demand and supply for new technology.

Great attention has been paid to the development in Germany of technical education and to the contribution that it made to German industrial advancement at the end of the Century. Not enough attention has been paid to the fact that this emphasis coincided with the development of industrial processes — primarily in chemicals and steel — which would make better use of the engineer and scientist than of the craftsman and tool maker. By accident or design, Germany developed an educational framework that meshed with the process requirements of the then current wave of industrial frontier. (Murphy, 1966, pp. 24-25.)

An interrelated aspect of high importance is the individual's behavioral bent toward acceptance and promotion, or rejection of innovation in any form. (Jolly, 1974, p. 3.) Without a positive motivator, alternately designated as "linker" or gatekeeper" in literature, the completion of the transfer process by actual utilization is notably diminished. The

apparent success of the People's Republic of China in developing "motivators" may well be the key to its observable growing success.

TECHNOLOGY TRANSFER: THE PEOPLE'S REPUBLIC OF CHINA

Heymann in "China's Approach to Technology Acquisition" succintly describes technology transfer from the USSR to the PRC.

> *The People's Republic of China has exhibited wide swings in its receptivity to foreign technology in the course of its 25-year history, oscillating between enthusiastic acceptance and determined rejection. In the 1950's — the era of close Sino-Soviet cooperation — China eagerly accepted what was undoubtedly the most comprehensive technology transfer in modern history. During that decade, the Chinese obtained from the Soviet Union the foundation of a modern industrial system. In the process, however, the Chinese became heavily dependent upon Soviet tutelage and were induced to adopt a Soviet model of forced industrialization inappropriate to China's resource endowment. In the late 1950's, the Chinese leaders began to reject this model and the overwhelming Soviet influence. The Great Leap Forward marked the reaffirmation of a more traditional Chinese nativism and self-assertion. Foreign technology and expertise were rebuffed and a policy of self-reliance instituted.* (Heymann, 1975, p. v.)

The trends in imports of industrial machinery and process plants may be viewed as a "bellweather" of the shifts in PRC technology infusion policy as shown in Figure 1.

The influence of Russia's contribution, which ran the gamut from scientific and technical education to project design, production, budgeting, and managing, (Ibid., p. 6), was seen as a mixed blessing if not a potential ideological threat. The resulting complete rejection, including in 1960 the withdrawal of Russian "experts", two concurrent crop failures, inept policies, and gross mismanagement combined to yield the cataclysmic short-term economic consequences of the Great Leap. A shift of priority favoring agriculture, a policy of inducing widespread "peasant" level innovation, and eventually a more permissive technology — import policy describe the rehabilitation era.

Heymann continues:

> *By 1965, the economy had largely recovered from its earlier setbacks and both domestic investment and foreign trade were again on the rise, only to be cut back once more by the turmoil and disruptions of the Cultural Revolution.* (Ibid., p. 10.)

The 1970 new wave of expansion, with the higher than before rise of both imports and exports, has seen also a very substantial growth of China's GNP. Quantitatively, imports in 1973 represented only 2.5 per cent of China's estimated GNP; however, qualitatively, they represent a crucial element in her economic development.

A look at another major developing industry will serve to illustrate both an overall correlation with the foregoing discussion as well as an interesting shift in geopolitics.

> *The Chinese objectives of self-reliance, relevance, collectivism, and distributed competence have resulted in industrial policies whereby each geographical and economic area must be capable of its own R&D production, and the computer and electronics in industry is no exception.* (Szuprowica, 1973, p. 598.)

The policy of in-house initiative and imitation, sometimes known as "reverse

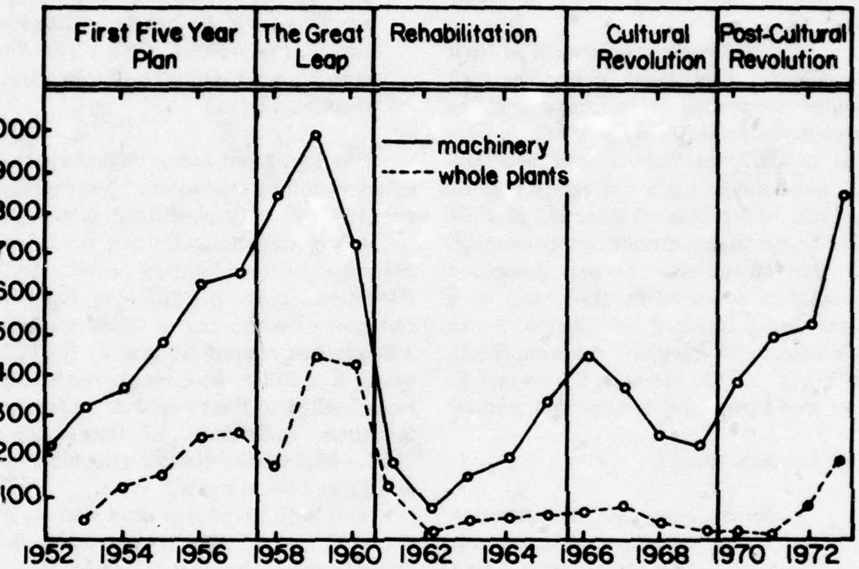

Figure 1 China's Imports of Machinery and Whole Plants, 1952-1973 (in millions of U.S. dollars)

The figure shows the increase in imports up to The Great Leap, which constituted the break in China-U.S.S.R. relations; there is a trend toward increased imports in the Post-Cultural Revolution.

engineering" is perhaps better illustrated in the computer industry than in machine tools and metals production. Szuprowicz states that,

> *In the 1950's China received considerable Soviet assistance, and the first Chinese digital computer, the August-1, unveiled in 1958, was based on the then uncompleted Soviet URAL-1. (Ibid, p. 599.)*

They had beaten the Soviets at their own game. One wonders whether such achievements helped to precipitate the abrupt end to Soviet aid in 1960.

In 1962, the Chinese with their DJS-21 had modelled a newer Soviet computer still under construction, and in 1964 had begun to incorporate semiconductors in their computers. Second generation computers appeared in 1966, and soon were being installed in Albania, North Vietnam, and possibly Pakistan. (Ibid, p. 600.) What has been the impact on our world presence, prestige and market?

Consider this:

> *British computer manufacturers enjoy the distinction of having sold the first western computers to China. A Marconi-Elliot ARCH 1000 was delivered in 1965, followed by an Elliot 803. ICL delivered a 1903 and a 1905 in 1967; both required U.S. approval because they contained U.S.-made components. Apparently the only purely U.S. computer in China is a Data General minicomputer. the NOVA 1200, obtained from Nippon Minicomputer Company, the Japanese licensee of Data General.* (Ibid, p. 600.)

Consider these facts together with Figure 2 and Table I, and the assertion that China's exports of computers, or as partly enabled by computers, are growing. What has been or may be the impact on the U.S. world Market?

U.S. computer scientists who visited China in 1972 were surprised at the evidence of advancement of computer science.

> *'We saw an operational third generation computer using integrated circuits, all home built. It puts them ahead of the Russians in this technology; the Russians have to import their integrated circuits,' said Professor Thomas E. Cheatham, Jr., Director of the Harvard Center for Research in Computer Technology.* (Ibid, p. 598.)

One significant factor might be termed education by exhibition. "A seemingly popular, but little-publicized vehicle of technology transfer to China is the industrial fair or technological exhibition." (Heymann, 1975, p. 25.) The logistics and cost of exhibiting in China are horrendous, but nations (apparently the U.S. being a notable exception) reportedly have flocked to the more than 35 foreign industrial exhibitions in China since 1971. Might a correlation with Figure 2 and Table I be indicated?

Yet, indications also show that while the PRC market may be extensive, the "reports from Shanghai indicate successful employment of a window handle factory force of 100 women in the production of magnetic cores, computer mainframes and transistors." (Szuprowicz, 1973, p. 599.) Many other localized conversions belie the "buy one and reverse engineer it" policy which has prevailed with the result that the "extensive market" has not materialized. Heymann contends that the program that has been truly successful is the extolling of the virtues of Chairman Mao

> *... maintaining independence, keeping the initiative in our own hands, relying on our own efforts and an arduous struggle, and building our country through diligence and frugality.* (Heymann, 1975, p. 13.)

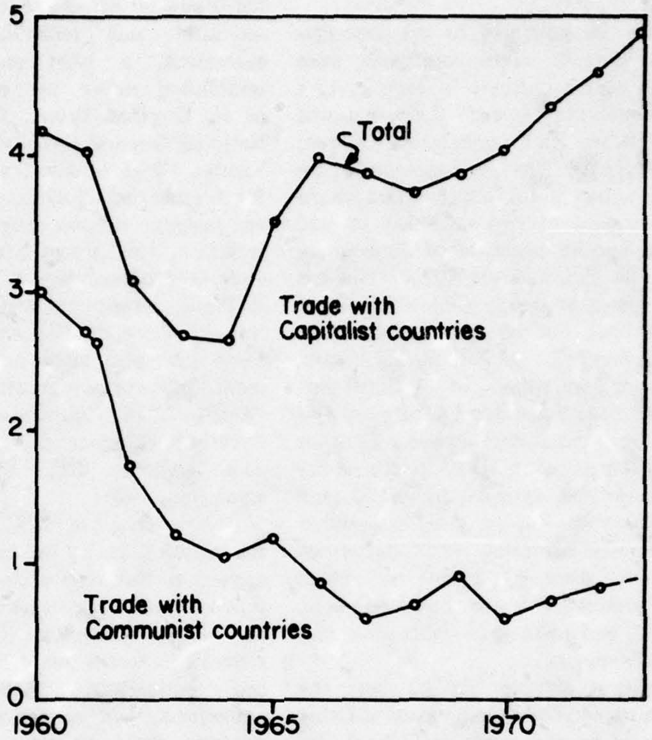

*Figure 2. People's Republic of China
Trade Trends in Billions of Dollars*

The Figure depicts a trend toward a decrease in China's trade with communist countries concomitant with an increase in trade with capitalist countries.

	1967	1968	1969
UK	1396	405	125
West Germany		343	18
Italy		162	1
Japan	1		76
France			37
Switzerland			7
Netherlands			2
Total	1397	910	266

Table I. Chinese imports of calculators, computers and office machines, in thousands of dollars

TECHNOLOGY TRANSFER: THE UNION OF SOVIET SOCIALIST REPUBLICS

"Modern weapons led to the bloc system of defense which represents, even for the senior partners in each bloc, a permanent erosion of their national independence and sovereignty." (Benn, 1971, p. 23.) The developments of resulting alliances for international security in recent history have led to and maintained the situation of detente between the U.S. and the USSR. Nor has the situation of greatly reduced communication been limited and directed only toward the U.S. Moreover, the central multi-year plan policies of the USSR government have engendered a primary emphasis on internal development. Little or no transfer of technology into Russia has been permitted, except perhaps by espionage methods; export of technology has been tightly controlled and limited primarily to other communist nations as noted previously where some economic, political, and ideological goals were concurrently sought.

Political detente has not been the only barrier to technology transfer. Other prominent barriers noted by Dehaven include:

1. Political and legal barriers which cause very costly and extensive arrangements to be required preceding any arrangements for technology transfer.

2. The Russian language when deliberately used as a communication deterrent.

3. Deliberate cold war psychology.

4. Wide differences in technical and physical standards and mechanical/electrical interface controls. (Dehaven, 1974, pp. 18-24.)

The net result of the foregoing is that, judging by the paucity of literature on the subject, little of a concrete nature is known about technology transfer within or with the USSR.

Wolfe points to the U.S.-Soviet agreement of May 1972 as the possible opening of the door. Under this scientific and technical cooperative agreement, a joint commission was established under the co-chairmanship of H. Guyford Stever, Director of the National Science Foundation, and V.A. Kirillin, Chief of the State Commission for Science and Technology. The avowed purpose of this commission is to facilitate technology exchange and undertake cooperative R & D in several fields; agreements regarding cooperation in space, health, and the environment were also made during this agreement, and working groups were formed. (Wolfe, 1974, pp. 1-5.) The Soyuz-Apollo joint space flight was a prominent outflow from this cooperative agreement.

Currently, the U.S. is maintaining the existing policy of rigid control of export of high-technology products and processes to the communist world. The number of controlled items has been reduced in recent years; however, advanced computers, telecommunications equipment, and numerically controlled machine tools are still absolutely restricted. This policy is enforced unilaterally by the U.S., and multilaterally with NATO countries and Japan under a mandate from Congress (1949) recently renewed. (Ibid., 1974, p. 8.) The spectre of potential enhancement of communist military capabilities still looms as a major barrier to policy change.

The Defense Advanced Research Projects Agency has initiated studies contracted by the Rand Corporation to:

1. Assist in formulating rationale for increased exchange and export of technology to the USSR, Eastern Europe, and China.

2. Investigate opportunities and methods for enhancing technology transfer to the U.S. from the USSR.

3. Investigate Soviet interests in

and capability for using U.S. computer technology and more generally aerospace technology.

4. Develop a dynamic mechanism to help assess the implications of technology transfer to and within the Soviet Union.

5. Explore other facets. (Ibid.)

Wolfe notes that Soviet inputs to research and development have been both extensive and sustained, and considers that there may be a profound need for or value in a national policy which would encourage import of technology from the USSR. (Wolfe, 1974, p. 10.) Some major developments which the Soviets have made have been in the areas of construction materials, metals, plastics, mastics, cold weather lubricants, and construction techniques under permafrost conditions. The last is a possible transfer of technique which could be made from the Russian tundra to Alaska. (Ibid., p. 25.)

With respect to study goal No. 4 enumerated above, which in fact could be a separate study in itself, Simpson contends that:

> *Such a dynamic mechanism would become a decision-aid tool that would assist national security planners to better resolve questions such as whether it is advisable to allow the Soviet Union to buy advanced U.S. technology, or whether some basic technology, if supplied to them, could enhance their military or commercial position and place the U.S. at a significant disadvantage.* (Simpson, 1975, p. 1.)

Simpson proposes to develop this dynamic model by studies and organizational analysis of:

1. Selected key Soviet central organizations which influence the technological environment.

2. The group of industrial ministries responsible for the implementation of technology within their respective sectors.

3. The expanding network of Soviet production associations.

4. Soviet production plants. (Ibid., p. 16.)

He well anticipates the challenge by noting that dealing with the Soviets requires persistence, patience, adequate financial resources, and hard-headed endurance. Therefore, much of the more traditional Western technology transfer experience can only cautiously be applied to the U.S.-Soviet relationship. (Ibid., p. 39.)

SUMMARY

This abbreviated survey of technology transfer with the Union of Soviet Socialist Republics and the People's Republic of China serves only to elicit consideration of the myriad problems associated with related public policy. To preserve and protect military security, world markets, technological prominence, and the interests of our American based multi-national corporations, and particularly to consider human and social impacts, are all goals which must be duly integrated during the formulation of U.S. national and international policies.

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Chapter 5

THE EFFECT OF CLIMATE ON FOOD PRODUCTION AND POPULATION

by

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ABSTRACT

We have been living in a period of benevolent climate. Food production has increased dramatically, but still has not kept pace with world population growth. This paper considers the impact of a possible change in climate on food production. While experts do not agree on whether the future climate will be warmer or colder, the consensus is that the climate is changing. There is the possibility that any change in climate will make the food situation worse, with a major change or shift in climate causing mass starvation.

INTRODUCTION

Background

There have been many treatises written about the problems of population. No matter what tack they took, the authors almost invariably focused on the difficult task of feeding the masses. Providing food for all people is the greatest problem confronting the world today.

It is disturbing that partial solutions are regressive in nature, only postponing the inevitable confrontation between population and food supply. Successful efforts to increase food production slightly result in reducing the numbers who starve to death. Those who live are then able to reproduce and, hence increase the total number of mouths to feed.

To keep demography and food production in perspective, many analysts make certain implicit assumptions regarding the stability of other factors, such as weather.

Objective

The objective of this paper is to tie the effects of climate to food production and hence to demography. The effects of both short-range and long-range changes in weather on food production will be considered.

Problem Statement

The scenario for tying together the inter-relationship among population, food production, and climate is based on the following syllogism:

1. The population of the world is growing at an alarming rate.
2. Grain is the major staple of the world.
3. Grain reserves are presently dangerously low.
4. The world is becoming increasingly dependent on the grain production capability of North America.
5. Many people are currently starving.
6. Any change in climate could be pernicious.
7. The weather is changing.
8. In trying to feed its future members, the human race will face its greatest problem ever.

The major thrust of this paper concerns the impact of changing weather on food production. First, however, the feeding of the masses in an environment characterized by a stable climate must be addressed.

DEMOGRAPHY

Recent Growth

One needs only to consider world population growth, shown graphically in Figure 1, to gain appreciation for the magnitude of our changing situation. The population of the world did not reach one billion until around 1835. Today,

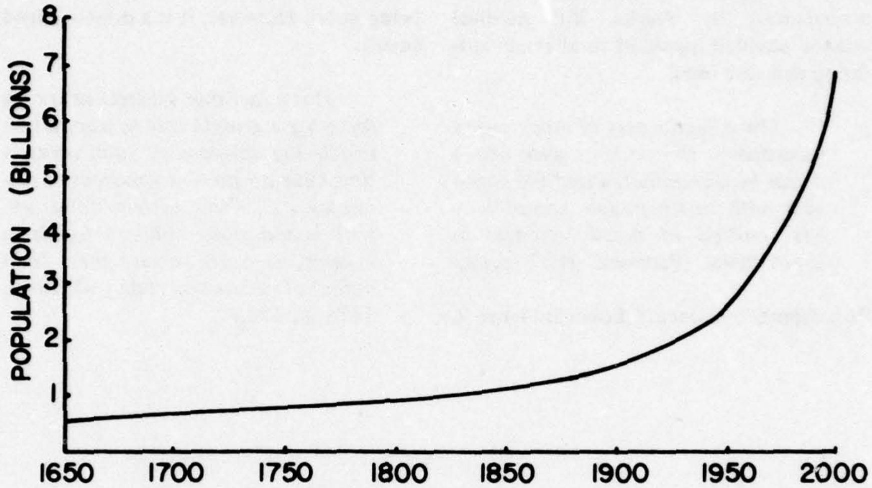

Figure 1. World Population Growth. (Source: Davis, 1963)

The figure graphically depicts the increase in world population growth; projections place total world population at 7 million by the year 2000.

there are four billion people and projections place the total citizenry of the earth around seven billion by the turn of the century. Since the earth is finite, this trend of increasing population will either have to change or confront some constraint.

In setting forth his Malthusian Laws, Thomas R. Malthus clearly recognized as early as 1816 both this tendency and the consequent constraints in the statement "Population has this constant tendency to increase beyond the means of subsistence." (1816, p. 9.) And even more poigantly he stated:

> ***. . . population, could it be supplied with food, would go on with unexhausted vigour; and the increase of one period would furnish the power of a greater increase the next, and this without any limit.* (Ibid., p.11.)**

While the demographic trend was accurately predicted early in the nineteenth century, its social implications have not been fully appreciated until recently. The population of the world is growing, but not evenly throughout society. Since 1930, the nonindustrialized nations have been growing in population about twice as fast as industrialized ones. (Davis, 1963, p. 124.) The pattern is quite clear: the world's poorest regions are making the greatest contribution to population growth.

Declining Death Rate

Population growth is not due to an increase in birth rate only. It is also caused by a decrease in death rate. For many years, the world's population was relatively stable; births were almost counter-balanced by deaths. But medical science enabled mankind to alleviate suffering and save lives.

> *The effectiveness of modern-day medicine — the rapidity with which it can be disseminated and the eagerness with which people accept it — has resulted in drastic changes in death rates.* (Paddock, 1967, p.16.)

This dramatic impact is shown in Figure 2. The decrease has been steady since 1935 and significant for all parts of the world.

The dilemma facing the world today now comes into focus. Technology developed in the advanced countries has enabled the less developed countries to lower their death rates. Most people will accept the contribution of medical science as being good. However, it is a double edged sword:

> *It is a fact that medical science is fostering a growth rate of population which the sciences of food production have no present prospect of sustaining . . . Only extremists at present would allow children to die in infancy, in order to save them from dying of starvation later.* (Vickers, 1974, p. 376.)

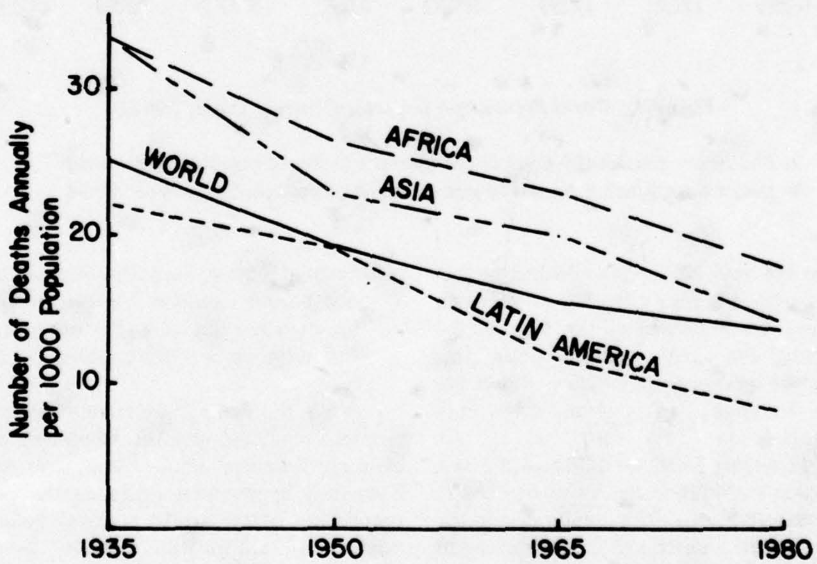

Figure 2. Death Rates of the World

Portrayed in the figure above is the dramatic decrease in the world's death rate in the past 45 years, the decrease is significant for all parts of the world.

FOOD

With the demographic pattern established, we may now turn to the second leg of the triad: food. Increasing population is not a problem per se as long as we, the citizens of this planet, can feed all of our cohabitants.

Increased Food Production

Technology has enabled us to increase our food production capabilities significantly. This increase is especially evident in the United States where

> *. . . the efficiency of the American agriculture and animal industry (make it) possible for 4.5 per cent of the population to produce enough food for the domestic needs of the nation as well as an exportable surplus . . .* (Borlaug, 1973, p. 8.)

Yields per acre have been increased four-fold as man has improved farming techniques, developed new seeds, controlled disease and insects, and built bigger and more efficient harvesting and processing machinery.

Decreased Reserves

In spite of these great strides, however, we are still losing ground. In 1971, world grain production reached an all time high. The United States has put into production all its cropland which had been held in reserve. Yet grain reserves have declined steadily until there is now only a 26-day supply. This deteriorating situation is illustrated in Figure 3.

Since plants represent 90 per cent of all human caloric intake, grain reserves are a good indicator of the world's food situation. Two very disturbing facts have emerged from the analysis of these data:

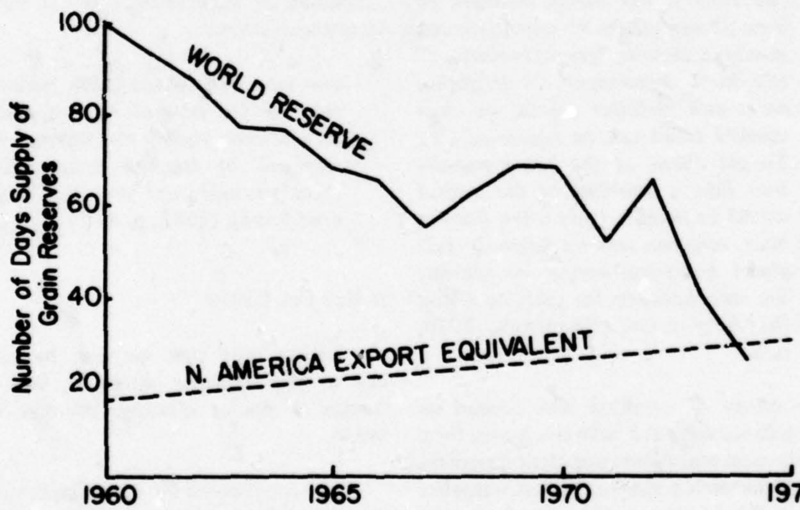

Figure 3. World's Grain Reserves

The figure portrays the decrease in the world's grain reserves since 1972 along with an increase in North American exports.

1. In spite of great increases in production in North America, reserves have fallen dangerously low.

2. The world is becoming increasingly dependent on North America for food. North America is essentially the only net exporting region in the world. These exports, representing approximately 10 per cent of all food consumed, make it quite appropriate to refer to this region as the Saudi Arabia of food. (Scrimshaw, 1974, p. 19.)

Population v. Food

Clearly, the race is on between population growth and food production. Production gains have been impressive, but when normalized to a per-capita basis these gains vanish. As Georg Borgstrom discouragingly concluded:

> *food production, both agriculture and fishery, has barely managed to keep abreast of the growth in human numbers. Despite "green revolutions" and hugh investments in irrigation dams and fertilizer plants, no clear upward trend can be registered . . . To get ahead of the rising population tide, a doubling of the output would be needed. Only when this has been achieved can we honestly talk about banishing hunger or winning the race between the grain crop and the baby crop!* (Borgstrom, 1973, p. 2.)

The future of mankind will depend on the balance achieved between future food production and future population growth. It will be such a close race that scientists and technologists are likely to determine the outcome. (Scrimshaw, 1974, p. 19.)

CLIMATE

We now come to the third and final leg of the triad: climate. Population and food production projections traditionally have been based on the assumption of a continuing benign climate: there may be fluctuations, but on a whole the weather will average out. But is this assumption realistic? Can we indeed count on a rather stable climate?

The Climate is Changing

Many experts think that the world's climate is indeed changing. (Climate is usually defined to be the average weather over a thirty-year period at a given locale.) These experts only differ as to how soon and in what manner it will change.

It May Get Warmer

Some experts, such as Dr. Howard A. Wilcox of the Naval Undersea Center, predict that man will eventually reject enough heat to the atmosphere, due to the burning of fossil fuels, that the average surface temperature of the earth will increase over 10^{o} F and cause the polar ice caps to melt. (1973, p. 36.) This theory is also supported by M. I. Budyko of the Soviet Union who states:

> *one may believe that with preservation of the present rate of energy production growth the thermal barrier will be reached comparatively soon (probably not later than a hundred years).* (1972, p. 873.)

It May Get Cooler

Others note that we may be heading in the opposite direction, that is, toward a cooler climate. Handler observes

> *. . . for reasons that are obscure . . . the mean temperature of the surface of the Northern Hemisphere has declined by .1 degree (C) per decade for three or four consecutive decades. That may sound trivial but it is not. A fall of not much more than two degrees would surely initiate a new ice age.* (1975, pp. 14-15.)

While no one is willing to predict an immediate ice age, Professor Reginald E. Newell of M.I.T. observes that

> *Every year we see the gradual buildup of ice in the Northern Hemisphere and we can record a temperature drop over the ice sheet. We have before us all the ingredients of an interglacial — glacial change.* ((1974, p. 34.)

Man v. a New Ice age

The difference between the two points of view lies in our estimation of the cause of the change. Those who foresee a warmer future point to man-induced changes. In a rigorous mathematical analysis of the energy balance of the earth-atmosphere system, William D. Sellers (1969, p. 399) concluded that man's industrial activities, if present trends continue, will replace solar energy as the primary energy input. Such a situation would lead to a climate much warmer than that of today.

Others note that earth's long history has been filled with many drastic climatic changes, and we are due — perhaps overdue — for another change. While we must be cautioned against trying to predict climatic changes based on past history, we do realize that the climate does indeed keep changing. There is no such thing as a normal climate. (Sutcliffe, 1966, pp. 178-184.) While solar activity and volcano eruptions can influence weather for a short period of time we still cannot determine the causes of climatic change. (Halacy, 1968.)

We cannot tell if we are heading toward another ice age. However, we do know that the earth's climatic system is very sensitive. Theoretically, conditions exist right now for the start of another ice age.

> *It appears likely that most of the climatic variability experienced during the Pleistocene epoch can be reproduced . . . without changing any variable. What apparently is needed, however, is an impulse or perturbation . . . to shift the climate . . .* (Sellers, 1973, p. 252.

David O. Woodbury puts the same idea into layman's language.

> *The amazing thing about an ice age is that it takes only a hairline decision of nature to start it and nothing more than the habit to keep it going.* (1962, p. 190.)

Consider, for example, Baffin Island, an arctic island in Canada. For 35 years before 1972, Baffin Island had been free of snow in summer. Now it is permanently snow covered. Since snow reflects approximately 80 per cent of the sun's radiant energy back to space, compared to 30 per cent for bare ground, this condition could be significant. An increase in reflected energy means a decrease in absorbed energy. A decrease in absorbed energy leads to a decrease in surface temperature, which in turn results in more snow. Without a break in the cycle, an ice age could be born.

There are other factors such as ocean currents and storm patterns that contribute to this shift in climate. Once started, a growing glacial ice sheet tends to change storm patterns because the ice sheet radiates heat, becomes cold and induces a high barometric pressure. Warm currents, such as the Gulf Stream, bring an enormous quantity of moist air to the area. When the moist air overruns the cold, it begins to snow, increasing the size of the young glacier.

The Sensitivity to Temperature Change

The sensitivity of the earth's climate to small changes in temperature is very impressive. An increase in average temperature of only 10° F is sufficient to melt the ice caps. A decrease of only 5° F could trigger an ice age. The average temperature of an ice age is approximately 16° F colder than that of the world today.

Also noteworthy is the "extreme sensitivity of the high latitudes of the Northern Hemisphere to factors which would produce climatic change." (Sellers, 1973, p. 252.) As we have seen, this area is where the world gets a major portion of its food. Any shift in climate in this area could have severe repercussions throughout the world. In other words, if we were to experience a minor change in the average temperature of the world, the Northern Hemisphere would probably experience a larger change. Food production would most likely decline in this region and affect the entire world.

One may still argue that an ice age (even if one is coming)or the melting of the ice caps (even if it does occur) is a long time away. But what we do know is that we are experiencing definite shifts in weather right now. In testifying before the Senate Subcommittee on Agriculture Production, Dr. Reid Bryson, Director of the Environmental Institute at the University of Wisconsin, stated that:

> *The evidence is now abundantly clear that the climate of the Earth is changing . . . Since about 1940 the Northern Hemisphere has been cooling off, rapidly approaching the levels of 100 years ago, but, more important than this cooling, the pattern of climate — especially the pattern of where the rains fall — has already been changing.* (World Food Situation, 1974, p. 129.)

The trends in temperature are shown in Figures 4 and 5. Figure 4 shows the average temperature of the Northern Hemisphere during the past century. Figure 5 shows the general trends of temperature changes in Iceland over the past thousand years. The temperature in Iceland is considered to be a good indicator of temperature patterns throughout the Northern Hemisphere. These data illustrate the continuing changes which make it virtually impossible to define any climate as "normal".

The Effect of Climate on Food Production

Dr. Bryson commented in *U.S. and World Food Situation* that these changes are detrimental to our capability to feed ourselves. His comment represents only part of the picture. The truth is that any change in the weather will be detrimental; any change in climate will be catastrophic.

During the past 40 years of benign climate, the population has doubled while agriculture has flourished. However, in spite of the favorable conditions we have not been able to build up our food reserves.

Any change in weather or climate will cause disruptions and at least a temporary drop in food production. If a rain belt shifts from an area of arable land to a desert, we might eventually be able to cultivate the now arable desert to replace the lost farmland. Unfortunately, this transition will take time which we don't have. Yields will be very low for several years while we are cultivating this land. In the meantime, we must realistically assume that famine will be great.

If the average temperature drops only 2^{o} F, growing seasons will be shortened by two weeks. Plant growth during the remaining season will be less vigorous. Crop yields may be expected to drop 27 per cent. With a 4^{o} F decrease in temperature, yields would drop to approximately 50 per cent. Such a result would truly be catastrophic.

If temperatures rose, the ice caps would start to melt. Many of the world's coastal cities would be flooded. Much of the world's best farmland would be lost. Furthermore, many crops would not do very well in the hotter weather. Many crops have been optimized to today's climate; any change will bring a lower yield. Increased growing seasons due to the hotter climate would not be able to compensate for the lost farmlands and lower yields. Again, the result would be catastrophic for a great segment of the population. Famine would be widespread.

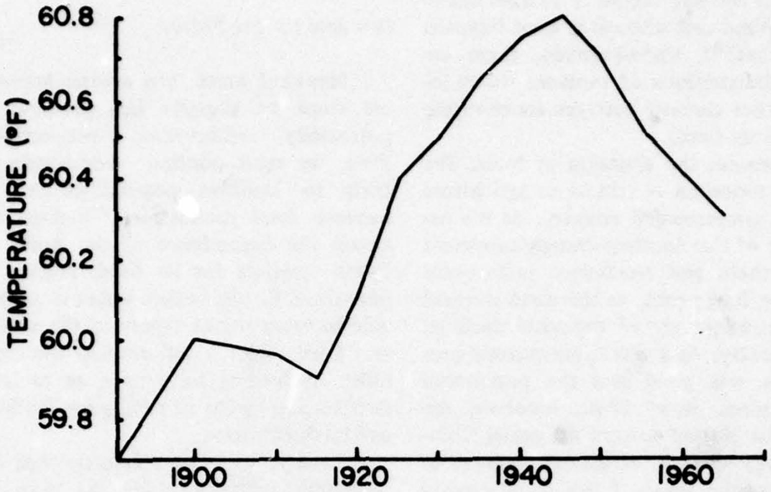

Figure 4. Mean Temperature of Northern Hemisphere
(Source of data: U.S. and World Food Situation, 1974.)

Figure 4 shows the average temperature of the Northern Hemisphere during the past century; from 1945 to 1965, the average temperature has dropped nearly .5° F.

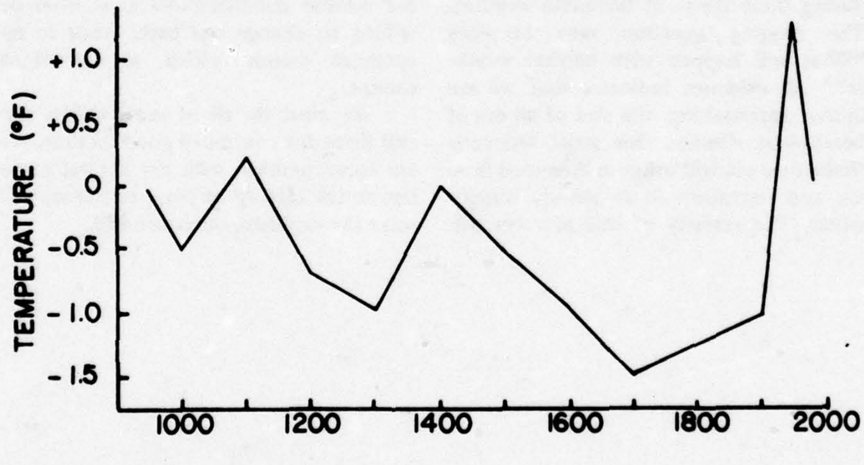

Figure 5. Mean Temperature in Iceland.
(Source of data: U.S. and World Food Situation, 1974.)

Depicted is the estimated mean temperature of Iceland which is considered to be a good indicator of Northern Hemisphere temperature patterns, for the past 1,000 years.

One may still wish to argue that these are long-range possibilities which may not actually happen ("at least not in my lifetime and who cares what happens after that?"). Unfortunately, there are ample illustrations of evidence which indicate that climatic patterns are changing at this very time.

Consider the situation in India. The Indian monsoon is critical to agriculture in that overcrowded country. At the beginning of this century droughts recurred in Northern and Northwest India every three or four years. As the earth warmed up the frequency of droughts declined significantly. As a result, agricultural production was good and the population quadrupled. Since 1940, however, the earth has started to cool off again. Coincidentally drought frequency appears to be increasing again. If this trend continues, the already severe food shortage in India will become very much worse.

CONCLUSION

It is quite clear that food production could not keep pace with population even during these times of favorable weather. The nagging question now becomes "What will happen with harsher weather?" All evidence indicates that we are indeed approaching the end of an era of benevolent climate. One must conclude that a new era will usher in increased famine and starvation to an already hungry world. The severity of this new era will depend upon the magnitude and timing of a change in climate.

Mandate for the Future

Mankind must take several immediate steps to alleviate this problem of potentially cataclysmic proportions. First, we must continue world-wide efforts to stabilize population and to increase food production. We must decrease the dependence of the world on North America for its food. Placing all our wheat in one basket makes us vulnerable to every minor vagary of the weather. Each region must develop the capability of feeding its people, or at least develop the means of paying for the food and its distribution.

Finally, we must recognize that the benevolent climate which we have enjoyed during the past is subject to change and is changing. We must increase international cooperation on weather reporting and forecasting. We must be ready to respond to changes in climate with plans to cultivate new areas. We must develop new strains of seeds which will grow under adverse conditions. We must even be willing to change our basic crops to reoptimize caloric yields as conditions change.

We must do all of these things and still hope for continued good fortune. We are faced perhaps with the biggest problem in the history of man. Either we will solve the problem, or nature will.

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Chapter 6

WORLD POPULATION EXPLOSION: A TECHNOLOGICAL, NOT FERTILITY, CRISIS

by

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ABSTRACT

The dichotomy of population growth rates between the developed and less developed countries is discussed. Some of the causes of this dichotomy are discussed in relation to the "demographic transition" model. A case is made that technological colonialism contributed to the population crisis and only its reverse, induced economic growth, will resolve the crisis.

INTRODUCTION

As we approach the twenty-first century, it would seem that the people of the United States are within grasp of a paradise on earth. Whereas one hundred years ago, mechanization, electricity, air travel, high living standards and the forty-hour work week were unheard of, all of these wonders are common in the United States today. However, the mood of the people is not one of confidence and anticipation, but one of concern for the long-term continuation of the human race as we know it today. The miraculous technological advancements of the United States and other developed countries (DC) have turned out to be mixed blessings.

The high standard of living of the DC appears to be threatened by the rapidly increasing populations of the less developed countries (LDC) and their anticipated demands on the world's limited resources. To avert a world population crisis, the DC have promoted widespread use of birth control techniques by the LDC. This approach has not resolved the real cause of the problem — economic stagnation and despair. Stockwell (1968, p. 175) discusses economic growth and its relationship to population growth and stabilization as "demographic transition."

Evidence suggests that the per capita technological and economic growth and the population stability of the DC was acquired at the expense of the LDC. Since the root of the population growth problem is economic, the solution should be economic. If the challenge of a stable world population is to be achieved, the economic status of the LDC must be raised so that the natural forces which stabilized the population of the DC will do the same for the LDC.

To gain an understanding of the magnitude of the problem, historical and projected population growth trends and the characteristics of the "demographic transition" model must be defined. With this background, the evidence for technological colonialism as a cause of the population crisis can be presented.

WORLD POPULATION GROWTH TRENDS

Man has populated the earth for some two million years. Down through the centuries the population has slowly but persistently increased. Prior to the eighteenth century, however, this increase had been rather undramatic in context with the size of the planet. Brown (1957, p. 3) reflects that this was . . . "the period when there was little change from one generation to the next . . . the days of the Black Death, of hopeless malnutrition and superstition, of ignorance and tyranny." Since then, dramatic increases in economic well-being and population have occurred. The population increase is shown as Figure 1.

The dramatic increase since the eighteenth century, to a present population of 3.5 billion, belies the slow steady growth of the previous two million years. "Historically, accustomed to slow and sporadic changes and the visible linearity of linked cause and effect, our latent assumption is that change is abnormal — that stability is the obverse of change. . ." (McHale, 1972, p. 4.)

The question that now concerns us is: "Will this new trend continue?" To explore this idea, let us look at some of the predictions of the population growth for the future. Predicting the growth

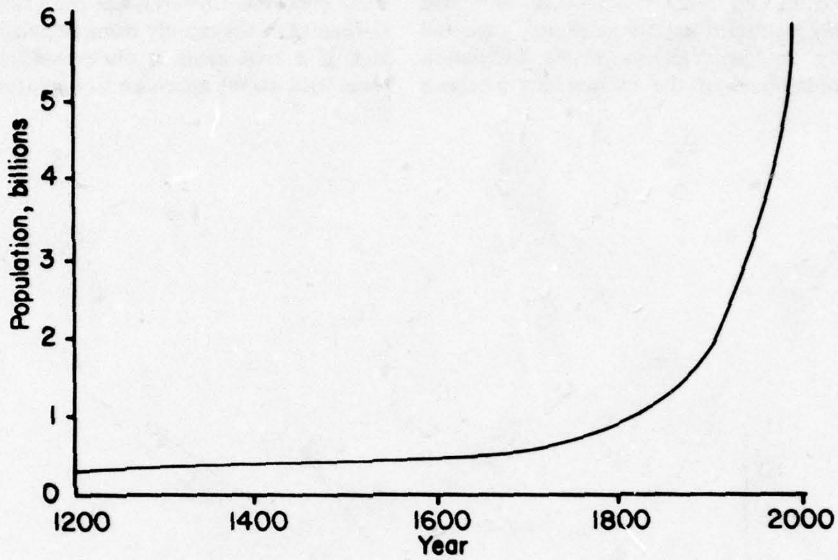

Figure 1. World Population (1200-2000 AD)

Depicted in Figure 1 is the dramatic increase in world population, beginning with the mid 1800's. A world population of nearly 6 billion is projected for the year 2000. (Source: McHale, 1972, p. 4.)

Attention is drawn especially to the increase in the proportion of the total world population expected in the underdeveloped regions — from 68.5 to 76.5 per cent. This will put severe pressures on the developed regions. (National Research Council, 1969, p. 56.)

of population is a difficult task, and must . . . "examine the growth on this planet — population, agricultural production, national resources, industrial production and pollution." (Meadows, 1972, p. 11.) These factors are interrelated and interdependent. The projections of several demographers who considered these factors are summarized in Figure 2.

These projections indicate that it took the world population approximately seventy-five years to double to the present 3.5 billion, but will take approximately forty years to double again to 7 billion people. Beyond the year 2000, confidence in the predictions wane and significantly different estimates are made depending on different fertility assumptions.

The doubling of the population in the next forty years, however, masks the fact that some countries, notably the industrialized countries, have nearly stabilized populations, while the populations of the LDC are growing at a rate significantly higher than the world average. This is depicted in Figure 3. (National Research Council, 1969, p. 56.)

As a result of the exploding population in the LDC, there has developed an

increasing concern about a population crisis. Can these numbers be fed? Will the natural resources be rapidly depleted by the requirements of the population today and of the tremendous increases expected? One cannot effectively dispel these concerns. However, one can explore the causes of the rapidly rising population and, if a root cause is discovered, shed some light on the approach to a solution.

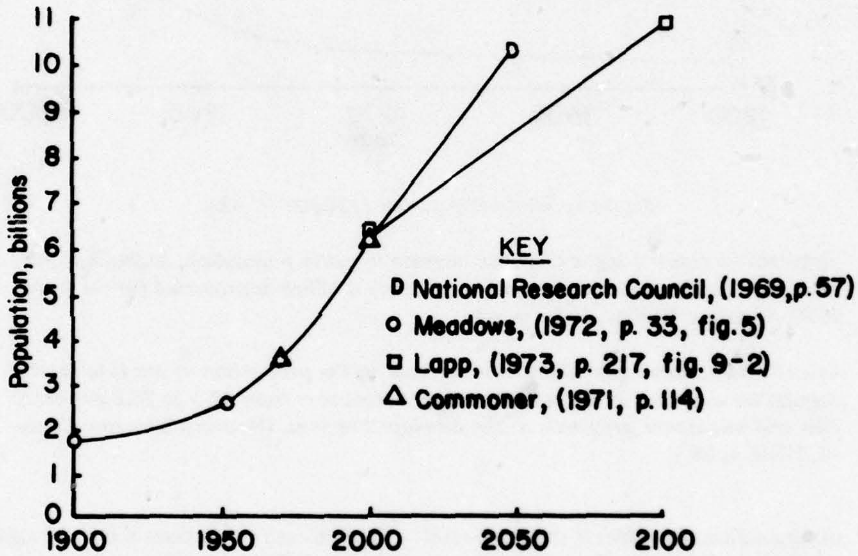

Figure 2. Composite Population Projections to Year 2100

Projections of world population to the year 2100 from four sources are illustrated. Note the divergence of opinion among the experts past the year 2000.

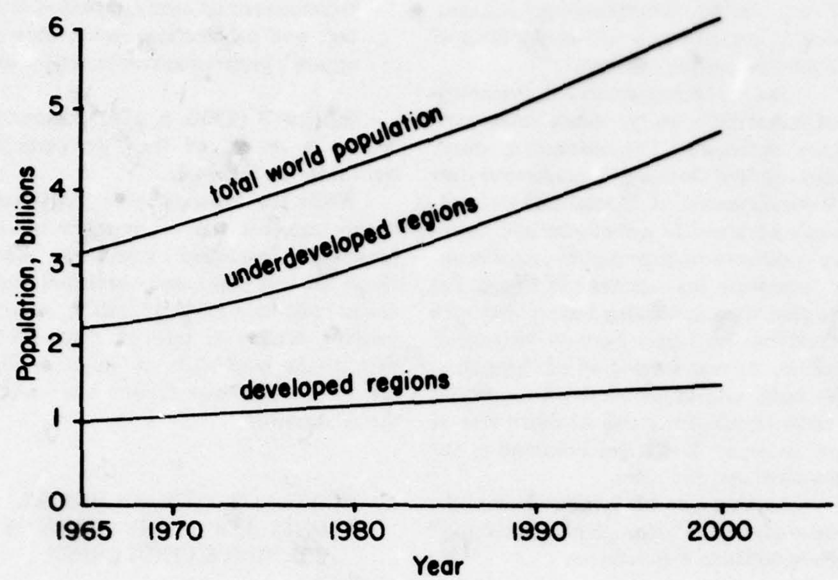

Figure 3. Population and Development, 1965 - 2000

The projected increase in total world population is attributed to the population growth rate of the LDC. The figure depicts a nearly stabilized population for developed countries.

NATURAL STAGES IN DEVELOPING A MATURE POPULATION (DEMOGRAPHIC TRANSITION)

Why is the population growth rate of the LDC larger than that of the developed countries? To determine this, we must first look at man's basic human reproductive influences. The birth rate is not only affected by biological factors, such as fertility and contraception, but by equally powerful social factors. The rate at which a population grows is determined by the difference between the birth rate and the death rate. Prior to the emergence of the agricultural/technologically oriented society, the birth rate was between forty-five and fifty births per one thousand persons per year, But, throughout this same period, the death rate very nearly equaled births. "A short life expectancy of about twenty years prevailed during the greater part of the time man led a food-gathering existence." (Brown, 1957, p. 44.)

As various societies adopted agriculture, their death rates dropped. As an increasing percentage of the world's population passed from food-gathering to an agrarian existence, the population multiplied rapidly. But as towns increased and population approached the limit of food production, pestilence, malnutrition and famine appeared, and the number of people who died each year approached the number of people who were born.

The average death rates increased to the levels which had prevailed during the days of the earlier food-gathering cultures. Society continued to live at the limit of its food producing capacity.

With the emergence of the technological/industrial society, death rates once again decreased. The decreasing death rates resulted from man's new power over his environment. As population increased, man's advances in agriculture and industry continued to grow rapidly, significantly increasing his standard of living. For the first time in his long history, industrialized man no longer lived on the edge of famine. As man's standard of living rose, the birth rate began to decline, until it nearly matched the annual death rate of ten to twelve deaths per thousand in the industrialized countries.

Chamberlain (1970, p. 8.) defines the above process as "demographic transition" and synopsizes it as follows:

> *Stage One characterizes pre-industrial societies. A high birth rate (four to six or more children per childbearing woman) is offset by a high death rate, producing a relatively stable population.*
>
> *In Stage Two, modern sanitation begins to make its entrance on the scene, a technological advance rather easily diffused. Other forms of disease prevention assist in curtailing the mortality rate. At first the greater number of surviving children helps to swell the population, but then the rising urban industrial and commercial middle class purposely limit the number of children as a means of improving their own status and securing the future of those fewer children.*
>
> *At this point industrial (or post-industrial) society has entered Stage Three. Social planning limits both the number of deaths and births. Once again population growth achieves a kind of stability, with only minor fluctuations, but now the balance between nature and man is a consequence of man's improved mastery and procreation, rather than of nature's impervious control over man.*

Stockwell (1968, p. 175.) succinctly defines a model of the "demographic transition" in Figure 4.

While the "demographic transition" model explains the occurrences of the presently developed countries, what about the less developed countries? Their death rates have declined, but an accompanying decline in birth rate similar to that of the industrialized countries has not occurred. Other factors must affect the relationship.

A CASE FOR TECHNOLOGICAL COLONIALISM AS THE CAUSE OF THE POPULATION CRISIS

In analyzing the current situation of the LDC, we will examine the causes of two aspects of the demographic transition.

1. The lack of per capita economic growth during the transition.

2. The rate at which the developed countries passed through the transition compared with the LDC.

Lack of Economic Growth

During the period of 1800 to the mid-twentieth century when the now-developed countries were passing through Stage Two of their transition, they required increasingly large amounts of natural resources to support their industrial growth. They satisfied this need through political colonialism. The developed countries exploited the LDC by taking their natural resources to fuel their own transition through Stage Two. Commoner (1971, p. 244.) states that the wealth of

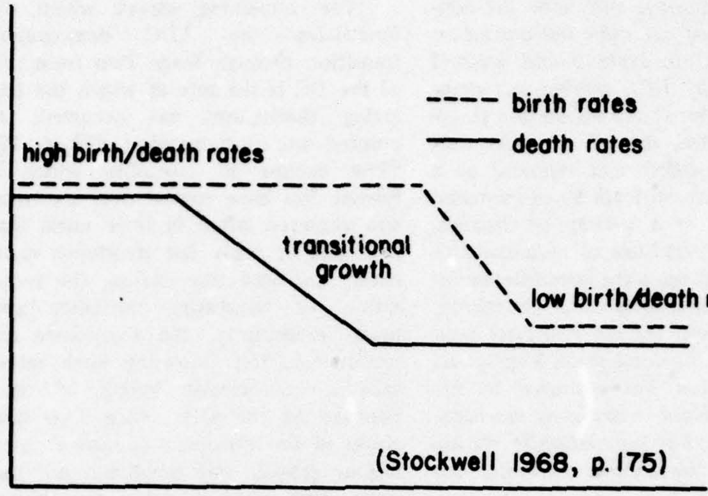

Figure 4. Demographic Transition Model

This model shows that the transition progresses from an initial balance of high birth and death rates through a period of sustained population growth to a new balance of low birth and death rates.

the advanced nations is largely a result of the application of modern science and technology to the exploitation of natural resources. He further clarifies his position with the following example.

> ***Thus, the Dutch brought into their Indonesian colonies modern techniques that improved living conditions and reduced the mortality rate in the native population. And, according to the anthropologist Clifford Geetz, who has made a careful demographic study of the colonial period in Indonesia, the Dutch apparently fostered the growth of the Indonesian population in order to increase the labor force that they needed to exploit the colony's natural resources. However, much of the wealth acquired as a result of the increased productivity did not remain in Indonesia. Rather, it was acquired by the Netherlands where it supported the Dutch through their own demographic transition. In effect, the first, or population-stimulating stage of the demographic transition in Indonesia became coupled to the second, or population-limiting phase of the demographic transition in the Netherlands — a kind of demographic parasitism. Then, in a final irony, with the postwar development of synthetic chemicals, Indonesia's natural rubber trade declined, further depleting the opportunities for the economic advancement that might support their own motivation for population control.***

Brown (1957, p. 47.) clarifies another aspect of colonialism as follows:

In India, for example, population was apparently at one time effectively limited in large part by recurrent famines. But with the construction of extensive transportation and irrigation systems and medical services (by DC), famine was virtually eliminated and population steadily increased. But all too often outright starvation was replaced as a major cause of death by an increased incidence of a variety of diseases. The susceptibilities of individuals to these diseases were accentuated by chronic and widespread malnutrition. Nevertheless, the net result has been to reduce the death rates. Thus a new phenomenon has appeared in the modern world — declining mortality and expanding population in the absence of significant economic improvement.

Unfortunately, the result of the above two analyses is stagnation in Phase Two of demographic transition; it is forcing the world into a population crisis. Rapid population growth soon becomes an anchor to economic growth rather than an aid. This is succinctly pointed out by Heilbroner. (1968, p. 68.)

The Aswan High Dam in Egypt — one of the most colossal engineering undertakings in any underdeveloped nation . . . will generate three times the total amount of electricity now produced in Egypt. Its overall impact on increasing agricultural production, may run as high as forty-five per cent. Meanwhile, however, that figure happens to be the percentage by which Egyptian population is estimated to rise in the ten-year period during which the dam will be under construction. Hence, despite the long term gain in power, the near term effect in raising the per capita living standards will be zero. The entire gigantic enterprise will only succeed in preventing the Egyptian economy from suffocating under its proliferating human mass.

Rapid Drop in Death Rates

The remaining aspect which differentiates the LDC demographic transition through Stage Two from that of the DC is the rate at which the triggering mechanism has occurred. As pointed out by Symonds (1973, p. 33), "The decline in mortality which in Europe has been spread over a century was achieved often in little more than a decade in many less developed countries." As with any change, the recognition of decreasing mortality and, more importantly, the acceptance and resultant action (lowering birth rates), take a considerable length of time. Because of the slow Stage Two transition in the European countries' populations growth was rapid but not runaway, and social adaption to lowering birth rates had sufficient time to assist, rather than retard, economic growth. Because of this slow process of social adaptation, one should not expect a rapid drop in birth rate to accompany the rapid decline in death rate unless a driving force is exerted. Without this social adaptation and other factors, economic development cannot succeed. Heilbroner (1963, p. 67) recognized this problem in stating ". . . that economic development, in the sense of a broadly based and shared upward climb, must wait on the establishment of social change on the grand scale."

The developed countries have now recognized this problem and are exerting influence in trying to reduce population growth by massive programs of birth control. These programs, however, have not met with resounding, uniform successes. This should be expected since as was pointed out in the demographic transition model, economic growth must accompany the drop in death rates in order to encourage a drop in birth rates. Heilbroner (1963, p. 113) recognized this and states that "Only uplifting the people and enlarging their cultural horizons will flatten out the curve." (i.e., population growth.)

CONCLUSION

We have just completed a presentation which discussed the alarming rate of the world population growth and contrasted the growth rate of the DC with the LDC. In focusing on the causes of the sustained high growth rates of the LDC in the absence of economic growth, we have shown this to be in contradiction with the demographic transition experienced by the DC. Some of the causes of this phenomenon were attributed to technological colonialism and its artificial triggering of the population growth rate. It is recognized that many other factors can and do influence the social and economic plight of the LDC. Focusing on the root cause of the stagnation of the LDC in Stage Two of the demographic transition, however, may help one develop better solutions to this problem. Since colonialism resulted in removing the wealth of the LDC to help the DC pass through the transition to a stable population, the reverse process may well speed the LDC through its transition. Commoner (1971, p. 247) summarized the task as follows:

> *Both the environmental and population crises are the largely unintended result of the exploitation of technological, economic and political power. Their solutions must also be found in this difficult area. This task is unprecedented in human history in its size, complexity and urgency.*
>
> *It is natural to seek for easier solutions. Since the basic problems are themselves biological limitation of population growth and the maintenance of ecological balance, there is a temptation to short-circuit the complex web of economic social and political issues and to seek direct biological solutions particularly for the population crisis. I am persuaded that such reductionist attempts would fail.*

The solution to the problem lies not solely in population control, but in hastening the LDC through the demographic transition by directing technological and political power to the task of inducing rapid economic growth. Because of the finite resources and food production capability, the consequences of failure in this challenge will be the resumption of nature's age-old method of population control: entire populations may be decimated by famine and disease.

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Chapter 7

THE COMPUTER IT LEADETH MAN TO THINK

by

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ABSTRACT

This paper discusses the possibility that the greatest benefit of the computer may lie in the fact that it forces those who work with it into more disciplined and thorough thought patterns. Three popular misconceptions about computers are discussed, and two major factors present in every computer application, the Dynamic System and the Total Systems Approach, are shown to be the main forces driving man into more disciplined thinking. The effect of this is extrapolated to the general population, and some possible impacts on technology and public policy are explored.

INTRODUCTION

To begin with, please note that the last word in the title of this article reads "think" and not "drink". Everyone knows that computers have driven many a man to drink (and deservedly so). Not many are yet aware that computers are leading men to *think*, perhaps not the way that Aristotle or Newton could think, but rather in the way the average person is capable of thinking, but rarely does. Until recently, many people have allowed a few others to do their thinking for them because genuine thinking truly is hard work.

The objective of this paper is to suggest that the computer may be changing this situation by literally forcing people to think in a disciplined, no-nonsense way. If this actually is happening, then it may be recorded someday that the computer was the greatest of man's inventions.

WHAT HATH MAN WROUGHT?

When it comes to computers this is a good question. Just what has man brought about? To paraphrase a familiar quotation from the *Book of Genesis*, "And man created the computer in his own image, in the image of man created he it."

In other words, man invested a machine that could process data in a manner somewhat analogous to the way his own mind works. His invention was successful, but it contained a "Catch 22" for which he had not bargained. The "catch" is this: the computer is designed to do exactly what man *tells* it to do, rather than what man *wants* it to do. Man, therefore, must cope with a machine that unfailingly, instantly, and without remorse, reveals his every error in thinking, even to the tiniest detail.

The impact of the realization of this fact has been so profound that even today, some thirty years after the birth of the computer, man has difficulty admitting it to himself. He still makes statements such as "the computer really fouled up my telephone bill," or "this listing the computer turned out is is pure garbage." But these attempts to shift the blame do not account for such mistakes any more than one can blame a firearm for shooting or a car for "accidently" running into a tree. Except in the rare case of mechanical failure, it is the man behind the gun, automobile, or computer who makes the mistake.

Increasingly man is coming to realize that the computer mirrors his thinking, and if he is to be thought wise, his thinking must be sound and true. We will discuss later in this paper how man is learning to do "sound and true" thinking. But first, we wish to dispel some emotionally charged, popular myths about the computer that tend to obscure the concept this paper is addressing.

POPULAR MYTHS

Several popular myths which seem to persist are that:

1. The computer will be the demon that brings about the Orwellian world of 1984,

2. Computer automation will put men out of work, and

3. The computer is a "Super Brain" that can really think.

The 1964 scenario is described vividly by Knelman (1971, p. 260) who warns

> *Whoever ran the computers could know when the individual entered the highway, and where he got off; how many bottles of Scotch or Vermouth he purchased from the liquor store; who paid the rent for the girl in Apartment 43; who went to the movies between two and four P.M. on a working day at the office; who was at lunch at Luigi's or the Four Seasons on Tuesday, September 15; and the hotel at which Mrs. Smith spent the rainy afternoon last Sunday.*

The key point made by Knelman is that just as man can misuse the computer, so can he misuse anything else. To prevent the 1984 scenario from becoming reality, we must control the "man who runs the computers."

With respect to the second myth, that computer automation will put men out of work, the myth still persists although it is not as prevalent as it once was. Walker puts this myth nicely to rest;

> *. . . the "obituary accounting" approach to automation ignores the fact that its primary benefit is likely to be in extending the boundaries of men's knowledge and enabling them to perform jobs that could not be done at all without automatic data processing.* (Walker, 1962, p. 326)

Turning our attention now to the "Super Brain" myth, Lapp pinpoints the kernel that disturbs many people

> *Furthermore the computer serves as more than a repository for facts; one can program into it instructions on how to respond (make decisions) to situations and even how to adapt to new situations on the basis of elementary learning. It is this capability that sends a chill down the spine of a layman; for he senses that man's three-pound computer will be no match for modern competition . . . the natural evolution of computers proceeds from the dumb stage to machines that will eventually take the THINK sign off the IBM office wall and incorporate it in their innards.* (Lapp, 1965, pp. 5-6)

This reminds the author of a recent cartoon where a scientist standing in front of a large computer is startled to see a paper issue from the computer on which is printed, "I compute, therefore I am." Gottlieb after much research into this area, assures us this is never likely to happen.

> *In spite of converging efforts by scientists from many disciplines, it is turning out to be enormously difficult to understand how memory, learning, recognition, and conceptualization take place in the brain. But the more it is learned, the more clear it becomes that present-day computers and computer programs are far too simple to be accepted as representations for these complex mechanisms and processes.* (Gottlieb, 1973, p. 149)

Having dispensed with these three popular myths, let us now turn our attention to how the computer is improving man's thinking processes. Basically, this improved thinking comes through greater discipline demanded by computer-forced use of (1) the Dynamic System, and (2) System Development. Each will be discussed in turn.

THE DYNAMIC SYSTEM

When man first began using the computer, he quickly discovered that what seemed to be a lengthy process actually involved only three basic steps:

1. instructions given to the computer
2. data given to the computer

3. information retrieved from the computer

Furthermore, he discovered that if the computer outputs fed back to him were incorrect, he could correct *his* thinking errors by

1. correcting his instructions to the computer

2. correcting the data he gave the computer, or

3. correcting both instructions and input data.

Once man had the computer performing to his satisfaction he found, to his delight, that he could exercise complete control in the same manner. Thus, the simple, but extremely important Dynamic System illustrated in Figure 1 was born (or, at least, rediscovered).

But how does the Dynamic Systems Model improve man's thinking? In two ways:

1. it provides him with a structure for which he *must* analyze and fit the problems he is trying to solve, and

2. it absolutely forces him to think through and account for every detail in every part of the system.

If he follows this disciplined methodology of thinking properly, he reaps the reward of success. But if he uses fuzzy or wishful thinking, or if he neglects to account for *every* detail, the system will not work and he must stand in the spotlight of failure.

The next question arises as to whether there is any indication that use of the Dynamic Systems Model has improved man's thinking. To answer that question look again at Figure 1 and replace

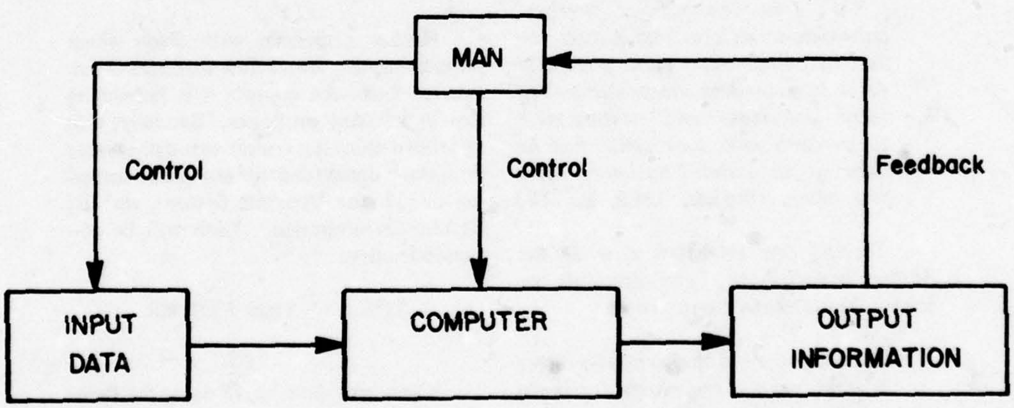

Figure 1. Dynamic System Model

The figure suggests that man exercises control over the computer by adjusting input data and instructions. This adjustment process reveals error in man's thinking and as a consequence, forces him to think in a more disciplined and thorough fashion.

"input data" with "material," "computer" with "factory," and "output information" with "products." Now we have a model of the recycling process that is so important today. As another example, take Figure 1 again and replace "input data" with "fuel/air mixture," "computer" with "internal combustion engine," "output information" with "combustion products," and "man" with "smog control device." Now we have an air pollution control system.

Is this similarity of systems purely coincidental? Or is there the possibility that after years of disciplined thinking forced by the computer application of the Dynamic System, man is now successfully applying this form of thinking to the increasing number of technological problems he is encountering? At this point, let us leave the questions that have been raised, to consider the other half of the picture which portrays the way computer technology may be causing man to improve his thinking System Development.

THE TOTAL SYSTEMS APPROACH

Having mastered the Dynamic System within the computer room, man was next faced with the much more difficult task of mastering the Dynamic System outside the computer room. In order to develop an automatic data processing program to do an improved job, he found that, starting from the beginning, he had to:

1. thoroughly understand the old method of doing the job;

2. devise a superior method of accomplishing it;

3. economically justify its net worth in dollars and cents;

4. specify every detail and oversee every facet of development;

5. train everyone involved in the program in how to properly provide the necessary inputs and effectively use the outputs;

6. implement the entire system to run smoothly; and

7. carefully monitor the system to maintain it in an operational condition.

Again, the computer was quick to tell if the analyst had made any mental mistakes in developing the system. By now, many other people were involved in the system. Ramo sums it up nicely:

> *Either we take the systems-approach route and perform well, or we accept absolute and utter confusion and chaos . . . For certain classes of problems, if you take away the compatibility, the harmony of the ensemble, if you fail to ensure the appropriate kind of interactions — in short, if you do not work the problem as the system problem that it really is — then you will have an absolute failure, not merely an inefficient compromise.* (Ramo, 1969, p. 27)

Anyone who has ever worked with computers will give a hearty "amen" to that statement.

Brown provides an example of what happens when total systems considerations are ignored:

> *The plight of the Sahelian zone countries of Africa is often blamed on several years of drought. While drought itself has certainly brought hardship and tragedy to these countries, a much more basic problem in the Sahel preceded the drought and will persist in destroying the productive capacity of the region if unchecked. The continuous growth in human and livestock populations beyond the*

carrying capacity of the area's fragile ecosystem has led to overgrazing and deforestation, creating conditions where the desert is moving southward at an accelerating rate. The drought has now brought these catastrophic trends into sharp focus. (Brown, 1975, p. 130)

The importance that total systems approach is having on the world is perhaps best exemplified by a commentator in *The Statesman*, Calcutta's century-old and most prestigious journal, whom Moynihan quotes:

It would be unwise for policy planners in the developing world to dismiss too easily ... the basic premise of a society that worships success: if you are poor, you have only yourself to blame. Development is a matter of hard work and discipline. So if you are not developing fast, it is not because the rules of the game are stacked against you or that structural changes are never easy to bring about, but because you are lazy or undisciplined. (Moynihan, 1975, p. 23)

COMPUTER-INSPIRED THINKING

Now that we understand the Dynamic Systems Model and the Total Systems Approach, let us return to the question of whether these disciplines are causing a greater number of men to increasingly think in a disciplined fashion. Sanders cites some revealing statistics:

In 1956, there were only about 600 computers installed in the United States; in 1970 the number had risen to 90,000; in 1975 the number is expected to be approaching 200,000; and it is predicted that 350,000 will be in use by 1980. (Sanders, 1975, p. 54)

No definitive Department of Labor statistics are available, but if we multiply the number of computers by only a modest factor it is apparent that well over 1,000,000 people are now subjected to computer-required thought disciplines. It might be inferred that never in our history have so many been required to think so well. *Toward the Year 2018* reflects upon this inference:

But perhaps the greatest change in the next fifty years will be in the way we look at the world — the world of both the physical and the human. For developments in memory storage, communication, and computers all weave together to make power of rationalization more attractive and more pervasive. Even now men are increasingly thinking of their activities, environments, and relationships in terms of rationalistic patterns as being the highest desiderata. It is in this respect that the computer looms as handmaiden to the rational scientific approach to human affairs.

But is there any demonstrated proof that man's thinking has improved because of the computer? The answer is that it may be too early to tell. In addition to the previously mentioned recycling examples, some possible examples that come to mind are that the systems approach was the key element in putting man on the moon, and that the public appears to be questioning proposed Federal spending programs with a systems approach.

The latter example illustrates that perhaps man's thinking has become more disciplined. Early in this century when the Teapot Dome scandal was revealed, people recognized that, like an iceberg, 90% of the problem was concealed. As a result, certain Cabinet officers went to jail. Three years ago, the Watergate affair came to light. This time, however, people recognized that the Watergate Problem was more than an 'iceberg'. For the first time in our history, the public demanded to know where the 'iceberg' was heading and from which 'glacier' it had originated.

And furthermore, from which 'mountain-top' did the 'glacier' originate? In short, for perhaps the first time, the total systems investigation approach was applied to a major national problem.

CONCLUSION

This paper has presented the suggestion that the true benefit of the computer to mankind may yet be unrecognized. This benefit results from the fact that the computer has forced a significant portion of our population to think more and in a more organized, disciplined way than ever before. If this is true, then the amplification of man's thinking ability applied to future technological problems is awesome to contemplate. In the words of Dr. Philip Handler, President of the National Academy of Sciences,

> *Mathematicians and solid state physicists gave us the digital computer. So profound is its impact that one may reasonably wonder whether in so doing, man has guided his own evolution — in the sense that a human being combined with a computer represents almost a new species.* (Handler, 1975, p. 1)

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Chapter 8

COMPUTERS, PRIVACY AND THE AMERICAN PUBLIC

by

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ABSTRACT

The computer has been part of our technological society for only twenty-five short years, yet its impact has touched the lives of all individuals. The brief ten year history of the computerized data bank as it affects the privacy of all Americans is outlined. The proposal for a National Data Center, which made the American public aware of the real threat to individual privacy, was formulated in the mid-1960's. It was not until 1974 that landmark legislation occurred with the passage of the Privacy Act of 1974. Since this legislation is aimed primarily at government data banks, the public wants still more comprehensive legislation to protect it from data banks in the private sector. There is evidence to indicate that such legislation will be passed in the near future.

INTRODUCTION

The objective of this paper is to show how a technological advancement, the invention of the computer, has led to a serious problem for the American public: the loss of individual privacy. This paper attempts to isolate when this threat became apparent to the American public and how this public is coping with it.

A Technological Advancement

When Charles Babbage, an English mathematician, put together his "Calculating Engine" in the early nineteenth century, "he sought to lighten the drudgery of those condemned to make laborious astronomical computations." (Mumford, 1970, p. 188) Mathematically oriented, his engine was designed to calculate and print mathematical tables. A few years later, Babbage turned his attention to his "Analytical Engine." It is significant to mention that this engine included a memory unit which could store data. (Arnold, 1969, p. 26) The modern computer was invented a century later. The modern computer can store not only data, but also instructions. Instructions are combined into programs which process the data and solve problems.

A Computer Revolution

Many people feel that this technological advancement, the invention of the computer, has improved their "quality of life." One has only to read a daily newspaper to find examples of how computer technology has benefited our society and government. In many fields such as space travel, education, medicine, business, and law enforcement, advances have been made that were only science fiction a few years earlier. As a result, in the past quarter century we have learned to rely on the capacity of the computer so that we may function in our society. With a "multi-billion-person society" the computer, mass data processing, and communication are absolute necessities. (Mestene, 1970, p. 86)

As we look into the future, we are certain that we will continue to rely upon the computer. In his book, *Future Shock* Alvin Toffler makes many predictions involving the influence of the computer on the individual. The book references the computer more than two dozen times in its index. Toffler says, "we have scarcely touched on the computer revolution and the far-ramifying changes that must follow in its churning wake." (Toffler, 1970, p. 216)

PRIVACY IN A TECHNOLOGICAL SOCIETY

Four Types of Privacy

We recognize that the norms of privacy differ among societies. Alan F. Westin has done a thorough study of privacy in America, including a study of data banks in a free society for the National Academy of Science (Westin 1972). In his book, *Privacy and Freedom*, Westin identifies four general states or functions that privacy creates for individuals and groups in Western democratic nations: solitude, intimacy, anonymity and reserve. (Westin, 1967, p. 32)

Solitude, the first state of privacy, is a situation in which "the individual is separated from the group and freed from the observation of other persons." In his/her second state of privacy, intimacy, the individual functions in a small unit and exercises a "corporate seclusion" such as in a family, friendship circle or work clique. His/her third state of privacy, anonymity, occurs when the individual is in a public place, such as riding in a subway or attending a ball game, "but still seeks, and finds, freedom from identification and surveillance." Reserve, his/her fourth state of privacy, is "the creation of a psychological barrier against unwanted intrusion." (Ibid p. 32)

This creation of mental distance, or reserve, acts by withholding information; this is the dynamic aspect of privacy in daily interpersonal relations. The manner in which the individual uses his/her reserve is the essence of securing meaningful privacy in the "crowded, organization-dominated setting of modern industrial society and urban life." (Ibid, p. 32)

Privacy Declines in a Technological Society

In *Technological Change*, Mesthene asserts that individual privacy declines in in a complex technological society. (Mesthene, 1970, p. 82) He offers the notion that individual privacy declines in two ways: involuntary and voluntary. The individual involuntarily experiences invasion of privacy when he/she is involved in such activities as the filing of an income tax return or becoming a victim of wiretapping. On the other hand, the individual may voluntarily trade some of his/her privacy for benefits that he/she values more highly. Examples of the voluntary trading of privacy would be having a telephone (and therefore being listed in the telephone directory) or in applying for social security benefits. (Ibid., pp. 82-83)

There are those who declare that the individual must be prepared to give up his/her privacy in an overpopulated and technological society. Ferkiss (1969, p. 227) says that fears of privacy completely vanishing "are based on the twin postulates of overcrowding and absolute surveillance." He later admits that, while societies may differ with regard to their definition and value of privacy, it is necessary to have some degree of privacy "for the maintenance of human self." (Ibid., p. 180)

THE PRIVACY THREAT UNFOLDS

The Gathering of Data on Individuals

It is a common belief that one makes better decisions with sufficient information. With insufficient information, one is more likely to make poor decisions. In presenting the defense for gathering of data on individuals by the government, Calder (1969, pp. 218-19) states:

> *Greater and more detailed information about individuals can make for more efficient government. It may also, if properly handled, lead to more humane government and greater attention to the individual's wishes and needs . . . Social research, census-taking, tax collection, public health inspections, criminal investigations and many other incursions into privacy are accepted as not merely sensible but desirable.*

In their book, *Social Issues in Computing*, Gottlieb and Borodin (1973, pp. 68-69) identify the types of data commonly gathered about individuals. Table 1 lists the nineteen types of data and provides an excellent backdrop as we watch the privacy threat unfold.

The National Data Center Proposal

In 1965, the Social Science Research Council received a committee report proposing that a National Data Center be

TABLE 1

TYPES OF DATA ABOUT INDIVIDUALS

1. **Identification**
   Name, maiden name (if applicable), social insurance number, date of birth, place of birth, citizenship, address, appearance, physical features, marital status, names of family

2. **Employment**
   Occupation, current employer, employment history, earnings, education and training, qualifications

3. **Medical**
   Current health status, medical decription and history, genetic factors, reportable diseases, x-rays, immunizations, dental history, health plan and participation

4. **Education**
   Schools attended, educational attainments, professional licenses, awards, loans

5. **Taxation**
   Earnings, investment income, foreign holdings, dependents

6. **Financial**
   Bank account history, holdings, earnings, credit and loan history, life insurance

7. **Military service**
   Rank and qualifications, service record, disciplinary record, medical record

8. **Vehicle registration**
   Owner, vehicle identification, origin, insurance, accident record

9. **Real estate**
   Owner, property identification, description, zoning, assessment and taxation, uses

10. **License and permits**
    Identification, type of license, dates, insurance

11. **Travel**
    Passport, visas, countries visited, customs and duty payments

12. **Welfare**
    Agency, history, dependents, aid received, earnings

TABLE 1 -- Continued

13.	Civil action History, court identification, dates, outcomes
14.	Police records Offenses, warrants, convictions, confinements, probation and parole, political affiliations
15.	Customer accounts Company, sales history, credit status
16.	Life insurance Identification, value, history, other insurance, medical data
17.	Mailing lists Type, source, customer profile, history of purchases
18.	Biographical Identification, curriculum vitae, accomplishments, publications, memberships, relatives
19.	Membership Organization, history, participation, financial, ralatives

The table lists 19 of the most common types of data gathered about individuals, as identified by Gotlieb and Borodin in their book **Social Issues in Computing (1973, p. 69, TABLE 5-1).**

established by the Bureau of the Budget. Edgar S. Dunn, Jr., a Bureau of the Budget consultant, recommended in a report that such a data center be implemented "to facilitate the efficient retrieval of information as government branches out into the more complex areas of poverty, health, urban renewal, and education, which require new and different uses of data." (Westin, 1967, p. 317) The news media expressed an alarmed and almost negative reaction to these recommendations.

Congress Stops the National Data Center

Congress entered the picture in the debate over a National Data Center with the creation of the Subcommittee on Invasion of Privacy, chaired by Representative Cornelius Gallagher. This House subcommittee did not investigate computers in 1965, but dealt with data surveillance in respect to government surveys which might infringe on the citizen's privacy. During the investigation, Chairman Gallagher remarked, "The magic of computers is helping (federal agencies) gather such a wealth of information from a variety of sources that all of us may someday stand psychologically naked." (Ibid., p. 315)

In 1966, the Gallagher Committee held hearings on computers and privacy with the National Data Center as the main topic. As the hearings progressed, it was revealed that the identities of any individuals or businesses reporting infor-

mation would have to be maintained, so that the validity of the data could be assessed. *It was now clear that privacy would not be assured!* Chairman Gallagher called the proposed National Data Center a "monster" and an "octopus". (Ibid., pp. 319-20)

Later in 1966, the President's Task Force on the Storage of and Access to Government Statistics (the Kaysen Committee) recommended that the National Data Center be established. The committee's report heavily emphasized the issue of privacy and called for legislation to assure privacy. (Ibid., p. 320) Computer privacy hearings were held in 1967 by a Senate Subcommittee chaired by Senator Long. The National Data Bank concept was eventually rejected in 1968 in House Report No. 1842, titled "Privacy and the National Data Bank Concept." (Gottlieb, 1973, p. 73)

The Privacy Threat is Apparent

Just as William F. Buckley, Jr. had observed a few years earlier, "More and more it becomes plain that privacy is the key to liberty" (Buckley, 1965, p. 455), the American public realized that vital freedoms were being threatened. Prompted by the proposal for the National Data Center, even the United Nations issued a statement showing concern for human rights throughout the world. (Hoos, 1972, p. 229)

Legislation Needed

There were no existing pressure groups, other than Congress and the courts, to sound effective warnings of the dangers of loss of privacy. (Kahn, 1967, p. 390) The courts had tried to cope with privacy problems under the common law. However, there were too many deficiencies in the common-law approach to deal effectively with privacy issues. (Miller, 1971, p. 187)

Attempts had been made to protect the individual by laws such as the Freedom of Information Act of 1967, the Omnibus Crime Control and Safe Streets Act of 1968, and the Fair Credit Reporting Act of 1969. (Gottlieb, 1973, pp. 77-78) However, in examining the legal problems of protecting privacy, it can be concluded that such laws are too narrow in coverage. "Umbrella" legislation dealing with privacy is needed.

THE AMERICAN PEOPLE GET LEGISLATION

Legislation is Introduced

Senator Sam J. Ervin introduced Senate Bill 1791 in 1969 primarily to draw attention to the problem of privacy. It limited the federal government data-collection activities to those authorized by Congress. (Miller, 1971, pp. 221-22) However, there would be many more bills on privacy introduced into Congress and five years would elapse before such a bill would become law.

Studies and Recommendations Follow

In June of 1974, the results of a study by the staff of the Senate Judiciary Subcommittee on Constitutional Rights was released. This study showed the scope of the federal government's collection of personal data on individuals. "The study found 858 data banks in 54 federal agencies, the majority of them not legislatively authorized." (Mathiasen, 1975, p. 293)

In another study, released in August, 1974, specific needs for privacy legislation were recommended by the Republican Research Committee's Task Force on Privacy chaired by Representative Barry M. Goldwater, Jr. The Task Force studied and made recommendations in the twelve specific areas shown in Table 2. (Frey, 1974, pp. 1-10, attachment)

TABLE 2

HOUSE REPUBLICAN RESEARCH COMMITTEE PRIVACY TASK FORCE, TWELVE AREAS OF RECOMMENDATIONS

Item Number	*Area of Recommendation*
1.	Government Surveillance
2.	Federal Information Collection
3.	Social Security Numbers/Standard Universal Identifiers
4.	Census Information
5.	Financial Information
6.	Consumer Reporting
7.	School Records
8.	Juvenile Records
9.	Arrest Records
10.	Medical Records
11.	Computer Data Banks
12.	Code of Ethics

Listed are the twelve areas of recommendations concerning the specific needs of privacy developed by Republican Research Committee's Task Force on Privacy, chaired by Representative Barry M. Goldwater, Jr.

SOURCE: Louis Frey, Jr., Republican Research Committee Chairman, to Republican Colleague, August 21, 1974. Files of Republican Research Committee Room 1620, Longworth House Office Building, Washington, D.C. 20515.

The Task Force followed eleven principles in making its recommendations, listed in Table 3. These principles could provide the nucleus necessary to form the "umbrella" legislation that is needed. Complete, accurate, timely, and relevant data are important to both government and business for effective operations. The Task Force did not oppose data banks as such, but did recommend strong safeguards against their misuse. In approving the recommendations of the Task Force, the Republican Research Committee Chairman, Representative Louis Frey, Jr. said, "These recommendations and the follow-on legislative efforts will ensure that the 1984 envisioned by George Orwell will remain only fictional." (Frey, 1974)

TABLE 3

HOUSE REPUBLICAN RESEARCH COMMITTEE PRIVACY TASK FORCE, PRINCIPLES OF INFORMATION PRACTICE

Number	*Practice*
1.	There should be no personal information system whose existence is secret.
2.	Information should not be collected unless the need for it has been clearly established in advance.
3.	Information should be appropriate and relevant to the purpose for which it has been collected.
4.	Information should not be obtained by illegal, fraudulent, or unfair means.
5.	Information should not be used unless it is accurate and current.
6.	Procedures should be established so that an individual knows what information is stored, the purpose for which it has been recorded, particulars about its use and dissemination, and has the right to examine that information.
7.	There should be a clearly prescribed procedure for an individual to correct, erase or amend inaccurate, obsolete, or irrelevant information.
8.	Any organization collecting, maintaining, using, or disseminating personal information should assure its reliability and take precautions to prevent its misuse.
9.	There should be a clearly prescribed procedure for an individual to prevent personal information collected for one purpose from being used for another purpose without his consent.
10.	The Federal Government should not collect personal information except as expressly authorized by law.
11.	That these basic principles apply to both governmental and non-governmental activities.

Eleven principles, which guided the specific recommendations of the Republican Research Committee's Task Force on Privacy, are listed. These principles could provide the nucleus for necessary "umbrella legislation."

SOURCE: Louis Frey, Jr., Republican Research Committee Chairman, to Republican Colleague, August 21, 1974. Files of Republican Research Committee, Room 1620, Longworth House Office Building, Washington, D.C. 20515.

Privacy Act of 1974

Soon thereafter, Representative Goldwater introduced his H.R. 16373 privacy bill accompanied by House Report 93-1416. During the same time frame that the House bill was passed, Senate Bill 3418, sponsored by Sam Ervin, passed the Senate. The Senate bill was amended to meet the House requirements and the compromise resulted in the passage of Public Law 93-579 in December 1974, known as the "Privacy Act of 1974." Representative William S. Moorehead, House Floor Manager of the privacy bill, called the measure 'the first comprehensive federal privacy law since the adoption of the Fourth Amendment to the Constitution.' (Mathiasen, 1975, p. 292)

The Act was aimed primarily at federal agencies. However, the Act established a Privacy Protection Study commission which can affect the private sector. This Commission is to study automatic data processing programs and data banks of both governmental *and private* organizations to determine standards and procedures for the protection of personal information. The Commission is to recommend legislation to the President and the Congress. (U.S. Congress, PL 93-579, 1974, pp. 10-15)

Nobody is "Against" Privacy!

While nobody is "against" privacy, the Privacy Act of 1974 and its Commission have been the topic of much discussion in both public and private sectors. It appears that "umbrella" legislation will result. Bradley gave a typical response to the Act and its Commission. He said that the Act "provided the major thrust to a continuing investigation of information processing and the threat to the privacy of individuals." Bradley further said:

> *So while the Commission does not have much power in terms of what it can mandate for private organizations, it does have the authority to investigate and study and, in this regard, I think it has a direct impact on all of us in data processing, whether governmental or private agency.* (Bradley, 1975, pp. 34-35)

In the March-April 1975 issue of the *Harvard Business Review,* we read:

> *We can now safely predict that within the next year or two privacy will affect every organization that has computerized data about people, for either the federal government will act to impose uniform laws throughout the country or the states will take action on their own.* (Goldstein, 1975, p. 63)

Goldstein's article, centered around the increased financial cost of privacy, asks the question "Who will pay?" While it is natural for the businessman to ask who will pay the financial cost for privacy, it is equally natural for the citizen to ask himself "Who will pay (i.e., suffer) for my *loss* of privacy?"

Comprehensive Right to Privacy Legislation

A little over twelve months after the Privacy Act of 1974 became law, Representatives Barry Goldwater and Edward I. Koch introduced H.R. 1984, on January 23, 1975. If passed, it would be called the "Comprehensive Right to Privacy Act." Its purpose is to protect an individual's privacy from state and local governments and any public or private entity engaged in industrial, commercial, or other similar business. It would insure safeguards for personal privacy by requiring such organizations to adhere to ten principles of information practice. These ten principles are the same as the first ten of the eleven principles delineated by the Goldwater Task Force (see Table 3). (The only other change is that the word "illegal" is deleted from principle number four in the bill.) If H.R. 1984 passes, it would establish a Federal Privacy Board to assist an individual unable to resolve a privacy dispute with an organization. (HR 1984, pp. 17-18)

CONCLUSIONS

Most of us have difficulty getting excited about problems until it's too late. When Alan Westin, Sam Ervin and Cornelius Gallagher were beginning to raise questions regarding the impact of personal recordkeeping upon our lives, most of us in data processing management failed to recognize the importance of what they were saying. Today, however, the future has caught up with us. (Orr, 1976, p.34)

This review of the brief ten year history of the American public and its bout with the technological advancement of the computerized data base and privacy brings us to the realization that the American public has awakened and is demanding the broad "umbrella" legislation needed.

Ten years of hearing and commission studies brought the Privacy Act of 1974 into law. As Representative Koch said after H.R. 1984 was introduced, "We need a broad federal policy to set the basic standard for privacy protection both in the public and private sector." He said that the H.R. 1984 bill number was "no coincidence." (*Computer Decisions*, June 1975, p. 24)

We know, as Americans, that implementing a bill such as H.R. 1984 may involve a financial cost to the individual in terms of increased costs of goods and services; but this financial cost, great as it may seem, would not compare to the higher cost of individual privacy lost in a setting of complete surveillance such as in George Orwell's *1984*.

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Chapter 9

PRODUCT LIABILITY, AND HOW THE ENGINEER AND SMALL-BUSINESS MANAGER CAN BE PREPARED

by

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ABSTRACT

An increasing awareness of product liability has arisen in recent years due largely to major product lawsuits and recalls, especially with automobiles. This paper discusses the effects of product liability on engineers and small-business managers and gives recommendations on how they can best be prepared to minimize product liability problems.

INTRODUCTION

One of the prices paid for the rapid strides made in science and technology is in the area of product liability, where the technical community currently faces a serious challenge. Thousands of cases are filed each year, increasingly involving engineers and manufacturers. Each year 30,000 Americans are killed, 110,000 permanently disabled, and more than 20 million injured in connection with the use of consumer products. (McGuire, 1973, p. 61) The number of cases on the dockets of United States courts increased from fewer than 10,000 in 1953 to 50,000 in 1963 and skyrocketed to more than 500,000 in 1973. (Starts, 1973, p. 11)

The growth of products liability laws must be viewed as a social development rather than strictly a legal one. The law is merely reflecting new and changing social, political, and economic conditions. In modern society, there is a trend to spread risks, to remove from the individual the burden of individual catastrophe, and to shift the loss to society as a whole. Insurance has played a major role in this changing social environment. Compensation for the injured party and protection for the public are today's legal guideposts.

To most manufacturers, the rapid evolution of product liability laws is likely to seem both irrational and unjust, and based on ignorance, and avarice, and fueled by politics. A widespread lack of understanding of the product liability problem by the business community has led to an astronomical number of claims, judgments, and large last-minute out-of-court settlements. It has also heightened the public awareness of its legal rights in cases of product liability accidents. It is the intention here to show the basis for product liability, how it affects engineers in various areas, and how a businessman can be alert to averting product liability problems.

LEGAL HISTORY

Early in the development of negligence law, the courts did not hold a manufacturer responsible for injury to another party unless there existed some kind of a contract between the two, giving rise to a relationship called privity. The typical interpretation of the law was that if privity did not exist, then there was no liability. The historical basis of this English common law rule dates back to a decision in 1842. In this case, Winterbottom vs. Wright, the plaintiff was the driver of a mail coach. It broke down, injuring the driver, who sued the manufacturer on the ground that the coach was defective. The court denied the claim, asserting that there was no contractual privity between the driver and the manufacturer of the coach.

For some time, even though the manufacturer could have foreseen injuries to others, his duty was limited only to those with whom he had contractual privity. This rule was later modified in the case of manufacturers of dangerous products, such as poisons and explosives, on the grounds that the manufacturer should have been able to anticipate the accident, and was therefore responsible even though there was no contractual relationship.

Another milestone occurred in 1916, in the case of MacPherson vs. Buick Motor Company, wherein the plaintiff claimed that his injury, caused by the collapse of a defective wheel, could have been prevented, had the Buick Company inspected the wheel properly. The court disregarded the wheel issue, but declared on a broader aspect, that a motor vehicle was a dangerous instrument, and, just as with explosives, privity would not be required for liability.

Further erosion of the privity rule led to a 1963 California case ruling, which has become the precedent for product liability cases throughout the United States. The court decision, relating to "strict liability in tort", means that a plaintiff in a product liability case needs only to prove that the product was defective when it left the control of the manufacturer and that the defect was the cause of the damages he suffered. He need not prove that the manufacturer was in any way culpable for causing the defect. In fact, as John V. Brennan of the United States Aviation Underwriters, Inc. describes the situation, "a completely faultless manufacturer can be held liable under the rule of strict liability. (Brennan, 1975, p. 44) All that is required is to show that there was indeed a product defect, which could be any one of the following: a) defective manufacturing, b) defective design, or c) defective marketing, in that buyers might have been misinformed about proper use of the product or potential dangers connected with its use.

Out of this background has come the current philosophy that a manufacturer of an article is liable for the injuries of the user, provided that the injury was caused by a defect in the product and the user used the product in a reasonable manner. Brennan describes the public policy considerations behind the application of the doctrine of strict liability in tort, as laid down in a recent court case, Branderburger vs. Toyota Motor Sales USA, Inc.

1. The manufacturer can anticipate some hazards and guard against their recurrence, which the consumer cannot do.

2. The cost of injury may be overwhelming to the person injured, while the risk of injury can be insured by the manufacturer and the cost of doing this can be distributed among the public as a business expense.

3. It is in the public interest to discourage the marketing of defective products.

4. It is in the public interest to place responsibility for injury upon the manufacturer responsible for its reaching the market.

5. This responsibility should also be placed upon the retailer and the wholesaler of the defective product, in order that they may act as the conduit through which liability may flow to reach the manufacturer, where ultimate responsibility lies.

6. Because of the complexity of present day manufacturing processes and their secretiveness, the injured plaintiff's ability to prove negligent conduct by a producer is almost impossible.

7. The consumer does not have the ability to investigate for himself the soundness of the product.

8. The consumer's vigilance has been lulled by advertising, marketing devices, and trademarks. (Ibid., p. 44)

Product liability defense is thus practically non-existent. The major question is whether an injury was caused by a defective product, and this question must be decided by a jury.

THE CONSUMER PRODUCT SAFETY ACT

A major extension of the federal government's involvement with product liability came with the passage of the Consumer Product Safety Act (CPSA) in 1972. Under this act, if a company makes or markets a consumer product or any of its component parts that company almost inevitably becomes accountable to the federal government — generally to the

Consumer Products Safety Commission, but to other agencies as well. The Chairman of the Commission, Richard O. Simpson, is described by Kiebala (1975, p. 34) as having made it clear that he and his staff of 750 people, working out of fourteen field offices, will enforce the law energetically, and that violations can result in fines of $500,000 and criminal penalties of one year in jail.

For most companies, however, the threat of penalties is not as ominous as the possible high cost of compliance. Should the Commission find that a product constitutes a significant safety hazard to consumers, it can order retailers, distributors, wholesalers, and manufacturers to recall, repair, or replace it, or to refund the price to the buyers. This action can follow the reporting of the existence of any substantial hazard. As required by the act, anyone involved in the manufacture, wholesaling, distribution, or sale of consumer products is required to report such hazards to the Commission within twenty-four hours of discovery. This emphasis on self-regulation will require basic modifications in most companies' response to problems of product liability.

On the bright side, one major benefit of the CPSA will be the eventual development of a unified national product liability code to replace individual state codes. This should simplify operations for companies whose goods are sold in more than one state, as can happen easily even without the manufacturer's knowledge. If the states eventually assume enforcement, individual state product liability codes are likely to be substantially identical.

Another major benefit of the CPSA will be the development, for the first time, of broad and reliable statistics on the performance of consumer products. A step in this direction has already been taken with the establishment of the National Electronic Injury Surveillance System. Under this system, 119 hospitals strategically located throughout the country report all injuries treated in their emergency rooms that appear to have involved the use of consumer products, These reports, which list accidents by frequency, type, and product, are published monthly and are available to the public on a subscription basis. They should prove invaluable to manufacturers in averting future problems.

THE DESIGN ENGINEER

The previously mentioned case of MacPherson vs. Buick Motor Company not only eliminated the privity rule, but also established the rule that the manufacturer has a duty to design and manufacture his product carefully so that it is reasonably safe for the use for which it was intended. This leads to consideration of one of the most serious areas of product liability: defects in design.

There are many failure-of-design situations for which the design engineer must be on guard. David Fromson, General Counsel of the National Fluid Power Association, groups these situations into three basic areas:

1. Where the concealed danger arises directly out of an imperfect design. Such was the case where the plaintiff sued the manufacturer of a die-casting machine for an injury sustained while operating the machine. The defendant's selection of a free-floating spool, for use in one of the valves of the machine, was questioned by the jury in light of expert testimony that the use of such a spool was unsafe.

2. Where the manufacturer neglects to furnish a needed safety device customarily used in the industry. Such was the case where a suspension plug designed for use with oil well equipment lacked a safety factor adequate to withstand the live load impacts. The result was that in three cases heavy equipment dropped 10,000 feet into the wells, making it necessary to abandon the remaining oil. In this case, the supplier of the equipment was held liable.

3. Where the design itself calls for materials of inadequate strength. Such was the case where the manufacturer was sued for injury when the disc of a wheel balancer attached to a rotating tire came off and injured the plaintiff. Plaintiff's expert testified that the disc came off because the failure occurred in the weakest section of the bolt, caused by improper design of the machine which resulted in metal fatigue. (Fromson, 1974, p. 100)

In reaching decisions, the courts are placing substantial reliance on determinations of whether a design has been accepted throughout the industry and whether other manufacturers use safer designs. Thus, it behooves the design engineer to be on the alert for possible defects before manufacturing ever starts. The place to start is in the drafting room, followed by a rather thorough design review. Efforts in this area will have other benefits as well. Jacobs (1975, p. 34) shows in Figure 1 how costs of implementing a design change can be lowered by use of a design review.

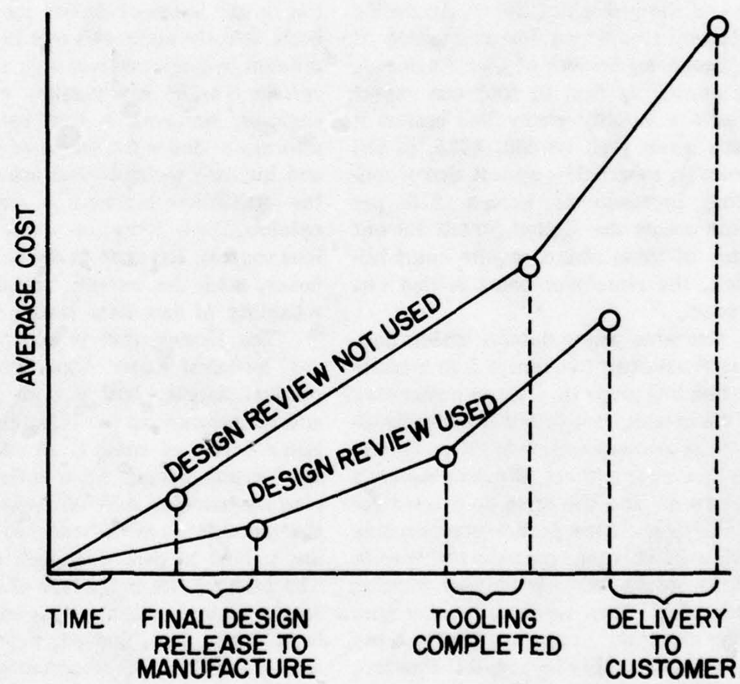

Figure 1 Cost Benefit of a Design Review

The figure illustrates that the use of a design review significantly reduces the average cost of a product's manufacture from the final design release to customer delivery. (Source: Jacobs, R.M., "Design Review: A Liability Preventer," *Mechanical Engineering,* August, 1975, p. 34)

He also shows, in Figure 2, a typical checklist to aid in the review process. The pay-off from a design review, then, is twofold: not only will it decrease the likelihood of future lawsuits, but it will also provide immediate manufacturing cost savings.

THE CONSULTING ENGINEER

Lawsuits against consulting engineering firms are a fact of life. If someone is injured on a construction project site, or if a client is unsatisfied with the quality of an apartment complex or the performance of a sewage collection system, the consulting engineer may well be sought out and charged with liability. According to Sidney Robin and Joseph Syrnick of the American Society of Civil Engineers, one consulting firm in four can expect to have a liability claim filed against it in any given year. (Robin, 1975, p. 66) Currently, new claims against design consulting professionals exceed 210 per month across the United States. Six out of ten of these claims require court litigation, the remainder being settled out of court.

One area where liability claims have an above-average frequency is in speculative building projects. A single owner may build and later lease or sell an office building or apartment complex. Often he will hire the same architect, the same structural engineer, and the same contractor for several jobs. These parties may become careless in drawing contracts and specifications because of their familiar working relationship. Then when something goes wrong on a job, it may be difficult to pin down responsibility to one of the parties, and litigation frequently follows. A liability claim is sometimes initiated by the owner, sometimes by the contractor, and sometimes by a third party. For similar reasons, it is most dangerous to start any job before contract discussions are finalized in writing.

While the engineer should not design over-defensively, he must constantly be aware that potential lawsuits lie latent on every sidewalk, roadway, and building site. When a professional offers his services to a client, he is an expert, accountable for a high performance standard within his area of expertise.

THE ENGINEER AS A TECHNICAL EXPERT

In the legal arena of product liability litigation, scientists and engineers are called upon to evaluate diverse products involved in injuries and to communicate their findings in an environment that often appears foreign to their own technical problem-solving processes. The culmination of the expert's testimony is his opinion on the issues of defect, causation, or both. It is the attorney's role to have that opinion delivered with as high a degree of certainty as he can possibly elicit. The engineer, however, is torn between the attorney's desire for increased certitude, and his own technological assessment of the limitations inherent in reaching his opinion. These limitations come from various sources: the state of the physical evidence, and the extent, adequacy, and reliability of data from testing programs.

The tension that is experienced by any technical expert who testifies in a product liability trial is both unhealthy and unnecessary to the litigation process. Some degree of stress is an integral part of decision-making when different conclusions based on different assessments of the same data can be reached: engineers are trained to deal with such dilemmas. The problem lies in the lack of communication between technical experts and the legal community. Indeed, a jury which senses this lack of communication may formulate its own theory of the case, rendering the engineer's testimony useless. Thus, a continuing substantive dialogue between the legal and technical communities is essential for the refinement of the product liability process; this dialogue must be one in which the engineer as a technical specialist can be true to himself while operating within a strong and responsive legal system.

1. General Manager Approval Date ____

2. Engineering Manager Approval Date ____

3. Product Selected is ________________________________

Approved by
(General Manager Date ________
(Engineering Manager Date ________
(Reliability Manager Date ________
(Designer Date ________

4. Chairman of Design Review is ________________________________

5. Secretary of Design Review is ________________________________

6. Participants (and Observers, if any) are:

a. ____________________ e. ____________________

b. ____________________ f. ____________________

c. ____________________ g. ____________________

d. ____________________ h. ____________________

7. Schedule:	Goal Date	Actual Date
Orientation Meeting	______	______
Design Review	______	______
Design Review Minutes	______	______
Design Review Final Report	______	______
8. Issuance of Orientation Notice	______	______
Issuance of Design Review Notice — Agenda	______	______
Issuance of Minutes	______	______
Issuance of Final Report	______	______

Figure 2. Design Review Check List

The figure shows a typical design review check list to be used to assure that all elements of an effective review process are addressed. (Jacobs, 1975, p. 34)

LESSENING LIABILITY

For the most part, businessmen have responded to the product liability problem by stressing production-related tasks such as purchasing better materials and improving quality control. While this approach is entirely proper, it is also incomplete. Needed is a more comprehensive, responsive approach which considers product liability from the perspective of the firm as a whole.

A checklist of factors that might be helpful in preventing a product liability problem from arising has been selected from recommendations to small-business managers (Olstrom, 1975, p. 9) and is presented as follows:

I. Establish objectives

   A. Creation of a safe product

   B. Safe performance under ordinary conditions

   C. Safe performance under extraordinary circumstances

   D. Accurate information to the buyer concerning product usage

   E. Coordination of information to marketing functions

   F. Acquisition of product experience records.

II. Develop a plan of action

   A. Engineering design review

   B. Manufacturing quality control

   C. Product use tests

   D. Review of product claims, as shown in advertisements, technical manuals, etc.

   E. Maintenance of close relationships with marketing personnel, wholesalers, and retailers

   F. Monitoring of relative environments, including:

      1. Product environment, by reviewing warranty card comments submitted by customers and technical information gathered from salesmen, customers, and competitors

      2. Customer environment by reviewing newspaper and magazine articles on product liability, customer complaints, and information gathered from salesmen

      3. External environment, by reviewing professional and trade association reports, industry journals, Small Business Administration reports, and Consumer Product Safety Commission reports

III. Prepare for contingency events by:

   A. Investing in adequate liability insurance

   B. Preparing a plan for:

      1. Response to customers

2. Withdrawal of products

3. Court action

IV. Assign organizational responsibility by:

A. Retaining overall responsibility for product liability at the top management level

B. Delegating day-to-day responsibility for product liability for product liability to one person

C. Making awareness of product liability organizationally permanent

The key issue for the firm is to recognize that this problem is of such importance that it demands a carefully planned action program. As noted above, it should include the establishment of objectives, development of a plan of action, assignment of the responsibility for its execution at an appropriate organizational level, and the communication of necessary information. Only through such an organized approach can an enterprise develop an integrated and effective strategy to meet the product liability challenge.

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Chapter 10

SOLAR HEATING OF HOMES: A TECHNOLOGY ASSESSMENT

by

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ABSTRACT

The energy from the sun is free; it is sure and continuous. Why not use it? Its application to heating of homes is a logical beginning, and mankind is finally moving in this direction. This paper is a brief assessment of the obstacles and implications of solar heating technology. U. S. Federal Government policy and programs are discussed as well as consequences for industry and business.

INTRODUCTION

The objective of this paper is to present a brief technology assessment (TA) of the use of solar energy to heat residential dwelling.[1] A major technological change such as solar heating is frequently accelerated by exogenous factors such as an oil embargo or a national energy crisis.

Fortunately, our national leaders are now recognizing the need for TA to provide themselves with the technical information needed to make rational decisions. This was demonstrated by the U.S. Congress when they enacted The Technology Assessment Act of 1972.

Energy from the sun is free and is expected to continue to be available for another five billion years. With these credentials, why hasn't solar heating had more widespread application? Solar heating of domestic hot water (DHW) was frequently used in this country up until the 1940's; and it is used currently in Australia, Japan, Israel, India and U.S.S.R. (ERDA, 1975, p. 2) Although cheap and convenient fossil fuels have made solar heating unattractive to much of the world, there are "hidden" costs associated with the use of conventional fuels — such as costs to future generations who will bear the consequences of our excessive use of natural resources, and environmental damage.

At the 1954 New Delhi Symposium, it was declared that heating of homes was one of the easiest ways to utilize solar energy; the symposium participants predicted that thirteen million homes would be solar-heated by 1975 if an accelerated program was adopted. (Daniels, 1956, p. 129) Obviously, this prophesy has not been fulfilled. Why not? This paper will explore some of the reasons why this technology transfer has been so slow.

GENERAL DISCUSSION

There are several alternatives to fossil fuels as energy sources. At this time, the two most practical are nuclear power and solar power. Solar heating power has the unique advantage over nuclear generated power of operating effectively on a very small scale: i.e., individual residential units. An added benefit of solar heating is the partial fulfillment of the homeowner's desire to be sulf-sufficient and live within nature's endowment. The homeowner, however, has been deterred from using solar power by the lack of available units and the relatively high cost of acquisition. Other deterrents to the widespread use of solar heating units will be discussed in a later section of this paper, but first a typical system will be briefly described so that readers may refer to a common conceptual system.

Figure 1 shows a typical residential solar space heating and DHW heating system. (Beck, 1976, p. 18) The basic components are:

1. solar collector
2. heat storage system
3. energy transfer fluid — usually water
4. source of supplemental energy

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1 A technology assessment may be defined as the systematic study of the effects on society that may occur when a technology is introduced, extended or modified, with special emphasis on the impacts that are unintended, indirect, or delayed. (Coates, 1974, p. 30)

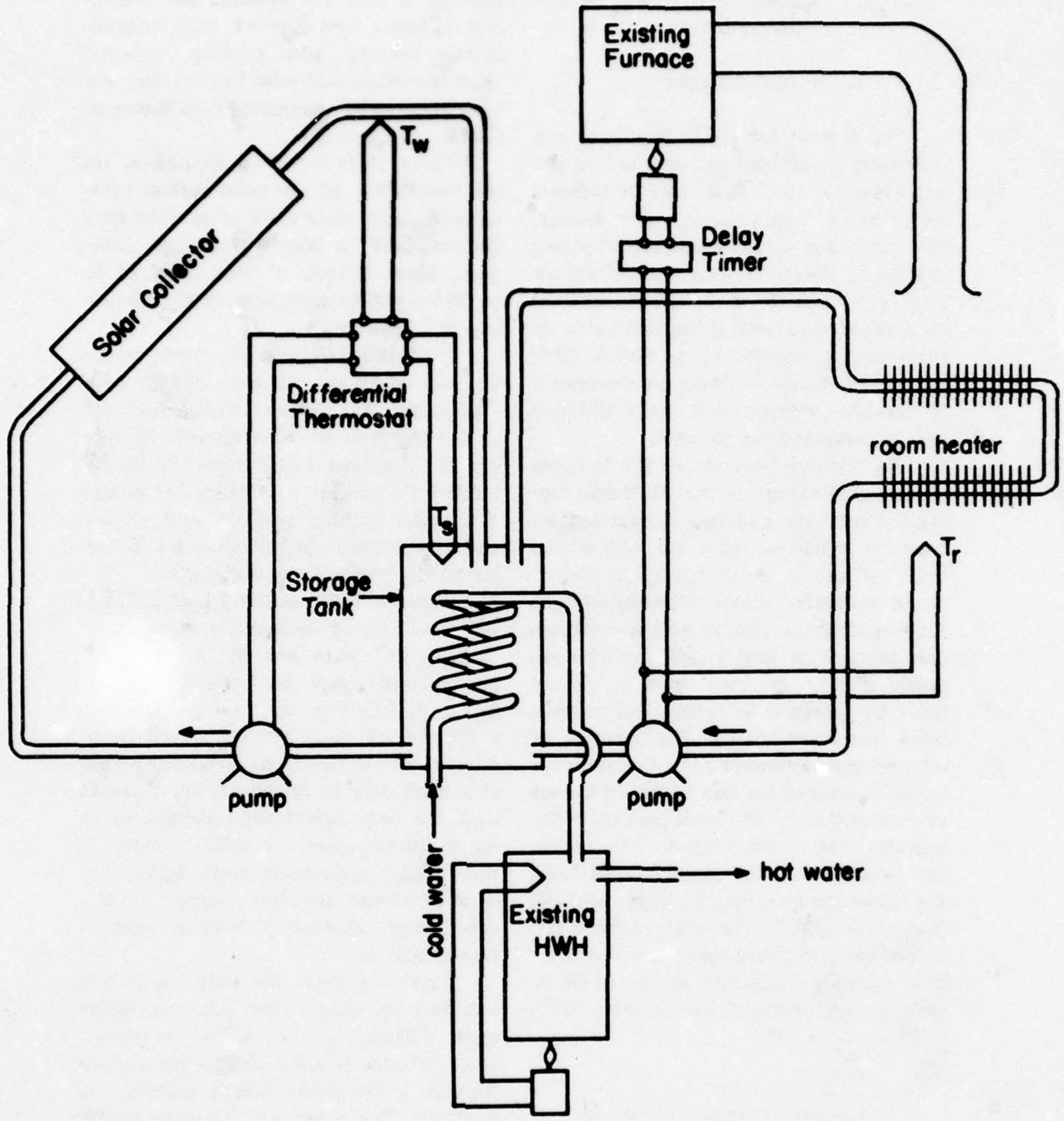

Figure 1 Conceptual Schematic For Space and DHW Heating

The figure shows a typical residential solar space heating and domestic hot water heating system with six basic components: 1) solar collector, 2) heat storage system, 3) energy transfer fluid, 4) source of supplemental energy, 5) space heating distribution system and 6) control systems.

5. space heating distribution system — air ducts or hot water radiators

6. a control system

The system for DHW functions is a tempering or preheating cycle before the water is raised to its final delivery temperature by a conventional water heater. This process is ideally adapted to heating swimming pools. A solar energy collection system can be more efficiently used on a year-round basis if heat-activated air conditioning equipment is added. This equipment would work on an absorption or Rankine refrigeration cycle utilizing heat generated in the summer.

An obvious obstacle to the harnessing of solar energy is that it is not constantly available, and so a storage system must be provided. However, about one-third of the solar energy generated is direct radiation, while two-thirds is diffused radiation. This is why a considerable amount of heat is still available on partly cloudy or hazy days. A system must be provided to collect and concentrate this solar energy. The amount of solar energy received at a location depends upon: a) hour of the day b) day of the solar year c) amount of clouds present d) the latitude, and e) the altitude. The higher the latitude and the lower the altitude, the lower the amount of energy received. (Beck, 1976, p. 1) However, regional variations in energy cost are more significant than regional variations in the available solar energy or insulation. (Glaser, 1975, p. 2)

DISADVANTAGES AND LIMITATIONS

One of the disadvantages associated with solar energy is that the systems are dependent upon the incidence of sunlight; therefore, those locations at latitude further from the equator, or those with frequently cloudy skies, will find such systems less efficient. Solar heating also performs worst in the coldest weather, when it is needed most. Another disadvantage is that the systems are considerably larger and heavier than conventional heating and cooling systems. Evidence exists that solar heaters *may* not have as long a life as conventional furnaces. (Beck, *op. cit.*, p. 3)

There is presently a limitation on the availability of the solar system components, and their level of performance and reliability is largely unproven. Likewise, there is lack of data required to optimize system designs to specific buildings and locations.

Possible restrictions of existing building codes and inexperience of city officials in dealing with new requirements act as deterrents to the development of solar energy. Financial institutions may be reluctant to provide mortgages for homes with solar heating systems, and private and government institutions may be reluctant to insure those mortgages.

There is the possibility that difficulties would be encountered with regard to "sun rights"; thus, new zoning and land-use patterns may be needed. (ERDA, 1975, p. 11) One can always fantasize a myriad of small problems, but these appear to be far from insurmountable and exist only in the short-run. It seems that the only significant impediment to rapid introduction of solar systems is their higher acquisition cost. Again, this is a short-run problem caused by the very small production volume (almost one-of-a-kind).

Currently there are only about one hundred buildings in the U.S. using solar heat. (Glaser, *op. cit.*, p. 10) A current cost estimate is eight dollars per square foot for a flat plate collector system, not installed. The price will decrease as the market steadily increases; however, this will occur much faster if the federal government offers incentives. (Ibid, p. 11) The nature of these incentives is a primary output of a major program coordinated by the Energy Research and Development Administration (ERDA) and involving the Department of Housing and Urban Development (HUD) and twelve other federal agencies. (ERDA, *op. cit.*, p. 59)

CURRENT ACTION

Current action is centered on the National Program for Solar Heating and Cooling coordinated by ERDA. This program is charted in Figure 2 and calls for a demonstration of residential and commercial heating systems by the end of 1977. The American Society for Testing Materials (ASTM) has a new subcommittee on Solar Energy Utilization for component evaluation, reliability and durability studies. Safety standards are being formulated by the American National Standards Institute (ANSI) to protect homeowners and commercial interests from substandard building equipment. (ASTM, 1975, p. 2) The Solar Energy Research Institute is in the final planning stages by ERDA. (Fannin, 1975, p. 3)

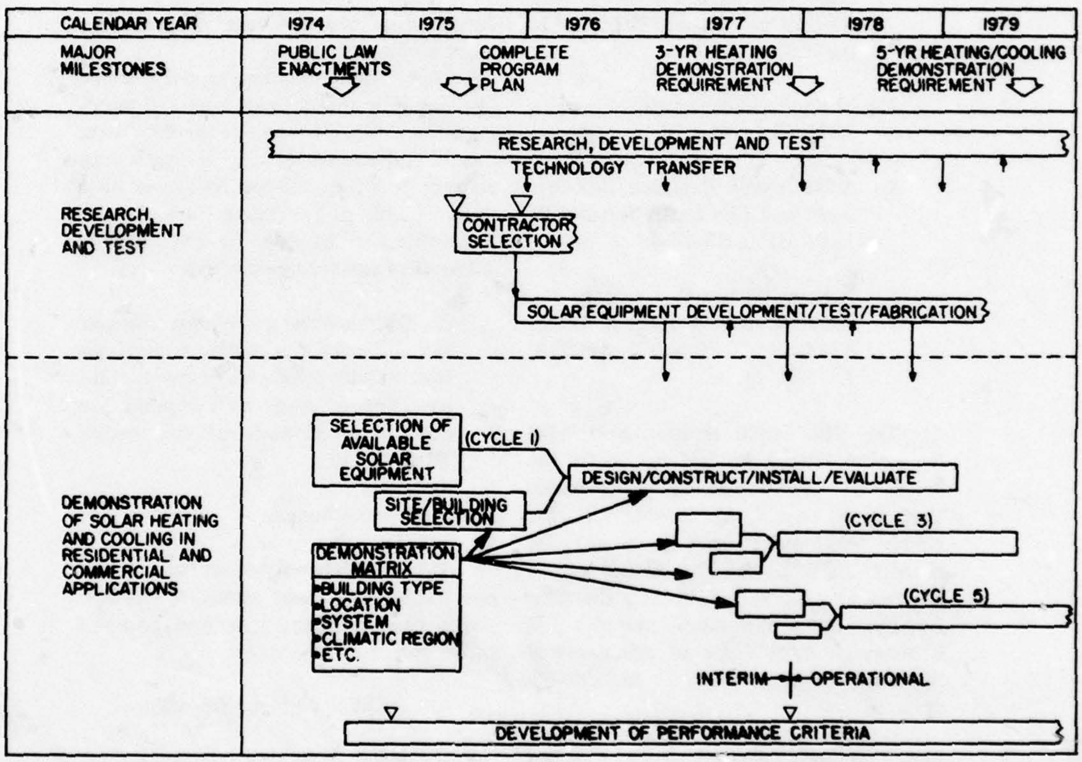

Figure 2 Summary Schedule of Federal Program for Solar Heating and Cooling

Depicted is a time table for Solar heating and cooling developed by a Energy Research and Development Administration; the schedule calls for a demonstration of residential and commercial heating systems by the end of 1977. (ERDA, 1975, p. 19)

Federal Government Policy

Beginning with the Water Pollution Control Act Amendment of 1972 (P.L. 92-500), Congress made its first attempt to measure implications and ramifications of specific public policy and its impact on our civilization. (Choates, 1974, p. 30) Several laws have been enacted which are guiding much of the current solar heating effort. These include:

1. Solar Heating and Cooling Demonstration Act of 1974. (P.L. 93-409)

2. Energy Reorganization Act of 1974. P.L. 93-438)

3. Solar Energy Research, Development and Demonstration Act of 1974. (P.L. 93-473)

4. Federal Nonnuclear Energy Research and Development Act of 1974. (P.L. 93-577) (ERDA, 1975, p. 1)

The U.S. Senate is now considering legislation similar to that passed by the House of Representatives (H.R. 6860) that would provide tax credits for solar energy equipment used in residences. (Glaser, 1975, p. 8) The overall goal of the federal program enacted by the 93rd Congress is to stimulate industrial and commercial capabilities to produce and distribute solar heating and cooling systems.

It is believed that without government stimulus, widespread application would not take place in this country before the end of the century. (ERDA, 1975, p. 1) However, it is hoped that as a result of the ERDA Program, solar heating and cooling will be competitive with other energy sources by 1980. The targets for new solar systems outlined by ERDA are:

1. 1980 — one per cent of annual residential and commercial building starts plus retrofit of 2500 residential units and 200 commercial units. This will save the equivalent of 10,000 barrels of oil per day.

2. 1985 — ten per cent of annual residential and commercial building starts plus retrofit of 25,000 residential units and 1000 commercial units. This will save the equivalent of 100,000 barrels of oil per day. (Ibid, p. 9)

Portions of the ten-year program are illustrated by Figure 3.

Since about twenty-five per cent of our energy is used to heat and cool buildings, the savings if even one per cent were heated and cooled by solar energy would amount to thirty million barrels of oil a year. (Ibid, p. 2) Frank Zarb, former Administrator of the Federal Energy Administration contended that:

> *. . . Solar heating and cooling can and should make a significant contribution to our total energy production by 1985 — going well beyond the goals of the demonstration program.* (Ibid, p. 71)

Needed Policy Changes

There are several public barriers and constraints that need attention through policy changes in the near term. Some of these are:

1. building code modification

2. land use, zoning and "sun rights"

3. property tax and assessment incentives

4. mortgage and home improvement financing based upon life cycle costing rather than acquisition costing

5. need for "truth in energy" labeling on solar systems to protect the consumer (Ibid, p. 58)

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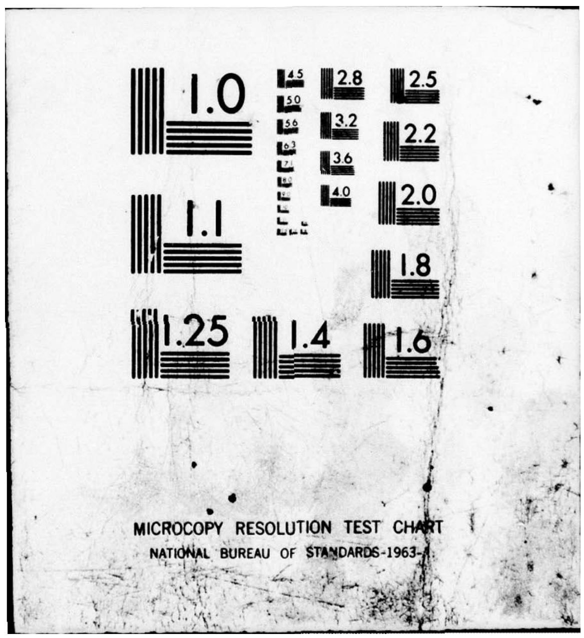
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NATIONAL BUREAU OF STANDARDS-1963-A

TABLE A-II-1

NUMBER OF ANNUAL HOUSING STARTS AND THE EQUIVALENT ANNUAL FUEL SAVINGS USING SOLAR ENERGY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Annual Starts [1]	0.1	0.3	1	5	20	50	70	100	150	200
Cumulative Starts [1]	0.1	0.4	1.4	6.4	26.4	76.4	146.4	246.4	396.4	596
Annual Fuel Savings [2]	2.4	9.6	33.7	154.2	636.2	1841.2	3528.2	5938.2	9553.2	14,373

[1] *In thousands of units.*

[2] *In thousands of barrels of all equivalent energy saved per year where:*

$$\frac{\text{Energy saved}}{\text{Dwelling unit}} = \frac{150{,}000\ \text{BTU}}{ft^2\text{-year}} \times \frac{1500\ ft^2}{\text{Dwelling unit}} \times \frac{\text{bbl}}{5{,}600{,}000\ \text{BTU}} \times .6 \text{ solar substitution} = \frac{225 \times 10^6\ \text{bbl} \times 0.6}{5.6 \times 10^6\ \text{Dwelling unit-year}} = \frac{24.1\ \text{bbl}}{\text{Dwelling unit-year}}$$

TABLE A-II-2

NUMBER OF ANNUAL COMMERCIAL STARTS AND THE EQUIVALENT ANNUAL FUEL SAVINGS USING SOLAR ENERGY

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Annual Starts [1]	0.01	0.03	0.1	0.5	2	5	7	1	15	15
Cumulative Starts [1]	0.01	0.04	0.14	0.64	2.64	7.64	14.64	24.64	39.64	54.64
Annual Fuel Savings [2]	3.2	12.8	44.9	205.4	847.4	2452.4	4699.4	7909.4	12,724.4	17,539

[1] *In thousands of units.*

[2] *In thousands of barrels of all equivalent energy saved per year where:*

$$\frac{\text{Energy saved}}{\text{Commercial unit}} = \frac{200{,}000\ \text{BTU}}{ft^2\text{-year}} \times \frac{15{,}000\ ft^2}{\text{Commercial unit}} \times .6 \text{ solar substitution} = \frac{300 \times 10^7 \times 0.6}{5.6 \times 10^6\ \text{Commercial unit-year}} = \frac{321\ \text{bbl}}{\text{Commercial unit-year}}$$

Figure 3. New Construction Schedules for the 10-Year Federal Program

The two tables outline the expected developments and equivalent annual fuel savings of solar heating and cooling systems for the ten-year period 1976-1985, under the federal incentive program administered by the ERDA.

Certainly, pollution is a worldwide problem and it will require some very imaginative and farsighted international cooperation. Solar energy systems may facilitate this cooperation as they become more competitive with fossil fuel systems.

SUMMARY

In the past, man has assigned high priorities to first-order effects, such as energy, at the expense of second-order effects, such as pollution. The development of all nations is directly related to energy; however, nations have regarded pollution as an evil but necessary price of progress. It was easier to simply move away from it (to the suburbs) than to work on reducing it. The world is now too small to just move away.

Factors that are helping to promote solar heating in the U.S. and, to varying degrees, throughout the world are:

1. rising conventional fuel costs
2. awareness of the need for energy conservation
3. governmental support for development of solar energy applications
4. increased availability of residential solar heating units, and
5. consumer desire to reduce dependence upon conventional energy supplies (Op. cit., Glaser, p. 8)

Many experts are certain that we will eventually depend primarily on controlled solar energy, but there are barriers which will slow its utilization. The primary barrier is the relatively high acquisition cost, while actually the life-cycle costs are lower. The federal government is moving to hasten progress through a program of research, development, demonstrations, incentives, technology transfer, and education.

The acceptance and use of solar systems will be very beneficial to U.S. industry, business, and commerce. It may be a new avenue to international technology transfer, increased world cooperation and ecological understanding.

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